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HAMPTON ROADS TRANSPORTATION PLANNING ORGANIZATION

HAMPTON ROADS HIGH SPEED PASSENGER RAIL VISION PLAN

November 2014

PREPARED BY

TEMS

TRANSPORTATION ECONOMICS & MANAGEMENT SYSTEMS, INC.

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Prepared in cooperation with the U.S. Department of Transportation (USDOT), the Federal Highway Administration (FHWA), the Virginia Department of Rail and Public Transportation (DRPT), and the Virginia Department of Transportation (VDOT). The contents of this report reflect the views of the Hampton Roads Transportation Planning Organization (HRTPO). The HRTPO is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views of policies of the FHWA, VDOT or DRPT. This report does not constitute a standard, specification, or regulation.

These opinions, findings and conclusion are preliminary in nature and do not represent final statements of fact or final projections of high speed and intercity passenger rail service to Hampton Roads. It is anticipated that upon completion of a NEPA Service Development Plan and/or TIER I Environmental Impact Statement, these initial study results will be refined to a level that supports the Hampton Roads Vision Plan for High Speed and Intercity Passenger Rail services from Washington D.C. to the Hampton Roads metropolitan area.

NON-DISCRIMINATION

The HRTPO assures that no person shall, on the ground of race, color, national origin, handicap, sex, age, or income status as provided by Title VI of the Civil Rights Act of 1964 and subsequent authorities, be excluded from participation in, be denied the benefits of, or be otherwise subject to discrimination under any program or activity. The HRTPO Title VI Plan provides this assurance, information about HRTPO responsibilities, and a Discrimination Complaint Form.

DISCLAIMER

This report presents alternative high speed and intercity passenger rail proposals that are un-negotiated, un-funded and at a feasibility level of analysis. It is understood that in following detailed environmental and engineering studies, the details of integrating the proposed passenger rail operations with Norfolk Southern and CSX freight operations will be subject to review, verification, and approval by both Norfolk Southern and CSX. Findings are not and should not be construed to be a commitment on the part of either Norfolk Southern or CSX to operate additional service.

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1. INTRODUCTION

This section provides a description of the background and purpose of the Norfolk-Richmond corridor Phase 2A Data Collection and the Phase 2B Alternatives Analysis studies, the scope of the work, and the organization of the Vision Plan.

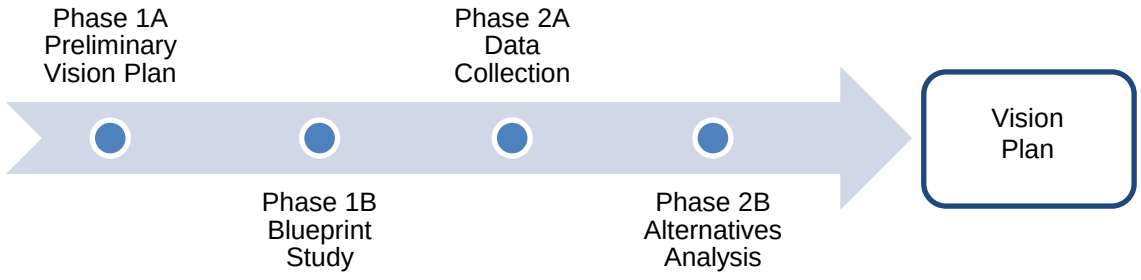
1.1 PURPOSE OF STUDY

The Virginia Department of Rail and Public Transportation (DRPT) developed the Richmond/Hampton Roads Passenger Rail Project Tier I Draft Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA) to develop conventional passenger rail service to the I-64/CSX corridor and the US Route 460/Norfolk Southern corridor. The state's draft NEPA document was released for public review and comment in December 2009. In February 2010, based on the evaluation and public comments received, the Commonwealth Transportation Board selected Alternative 1 as the preferred alternative for enhanced passenger rail service between Richmond and Newport News and higher speed passenger rail service between Petersburg and Norfolk. DRPT has completed the Tier I Final EIS document, which was circulated for public comment in August 2012. The Record of Decision (ROD) was approved by the Federal Railroad Administration (FRA) on December 7, 2012.

The Final Tier 1 EIS proposes 6 trains per day at 90 mph from Norfolk to Richmond and Washington D.C., and 3 trains per day from Newport News to Richmond and Washington D.C. To support and further develop the Commonwealth's efforts, the Hampton Roads Transportation Planning Organization (HRTPO) Board approved a resolution in October 2009 that endorses the designation of a "high speed rail" corridor with ultimate speeds of more than 110 mph along the Norfolk Southern/Route 460 (Norfolk-Richmond) corridor and that enhances the intercity passenger rail service along the CSX/I-64 corridor (Newport News-Richmond).

TEMS was commissioned to develop a Vision Plan for passenger rail service for the Hampton Roads region that implements the HRTPO objectives established by the Board. An initial phase (Phase 1) of work was completed by TEMS in July 2010. Recent and current work on Phase 2A Data Collection and on Phase 2B Alternatives Analysis work is designed to build a database and an evaluation framework for identifying the potential for high speed rail in the Norfolk-Richmond corridor, and for higher speed rail in the Newport News-Richmond corridor. See Exhibit 1-1. The current report describes the data collection process and the evaluation of routes and technology options needed to complete the Hampton Roads-Richmond Corridor Vision Plan. The Vision Plan includes the analysis needed to support the preparation of a Service Development Plan (SDP) and Service NEPA that are the key documents needed by U.S. Department of Transportation (USDOT) FRA to support further planning work on high speed rail for the Norfolk-Washington D.C. corridor.

Exhibit 1-1 Overview of Study Development Process



1.2 DEVELOPMENT STEPS – NORFOLK-RICHMOND CORRIDOR

Exhibit 1-2 shows the four step process envisaged by DRPT and HRTPO for developing passenger rail service. Development Steps 1 and 2 (79-90 mph) come under the DRPT's focus on conventional passenger rail service, while Steps 3 and 4 reflect the HRTPO's "higher and high speed" rail focus of the HRTPO. In terms of Step 1 and Step 2, DRPT has made good progress in starting an Amtrak 79-mph service to Norfolk. The service was started in December 2012 and provides a daily direct connection from Norfolk to Petersburg, Richmond-Staples Mill, Washington D.C., and connections to the Northeast corridor. Development Step 3 and Step 4 are the focus of the HRTPO planning process to develop high speed rail for the Norfolk-Richmond corridor.

Exhibit 1-2: Proposed System Development Steps for the Norfolk-Richmond Corridor

Steps	Route	Max Speed	No. of Trains	Infrastructure	Station
Step 1	Route 460/ Norfolk Southern**	79 mph	1-3*	Shared Track NS	Staples Mill Only Norfolk
Step 2 (FEIS Opt 1)	Route 460/ Norfolk Southern**	79-90 mph	4-6	Shared Track V Line	Main Street Bowers Hill
Step 3	Norfolk-Richmond along Route 460	110 mph	8-12	Dedicated Track V Line	Main Street Bowers Hill
Step 4	Norfolk-Richmond along Route 460	150 mph	12-18	Dedicated Electric Track V Line	Main Street Bowers Hill

* Two additional trains are planned in the near future by DRPT.

** Norfolk Southern (NS) does not permit passenger train maximum authorized speed in excess of 79 mph on any NS track. Where the V-line (former Virginian Railway) has existing freight services, maximum authorized speed for passenger trains will be 79 mph. Along the Algren – Kenyon portion of the V-line (over which NS freight rail service has been formally abandoned); passenger rail planners may consider speeds above 79 mph. Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger trains utilizing it or encroaching upon it.

1.3 SCOPE OF THE STUDY

Phases 2A and 2B of this study provide the basic data needed to plan for "high and higher speed" passenger rail service in the Hampton Roads-Richmond corridor, as well as the analysis of route and technology options that should be considered for the Vision Plan.

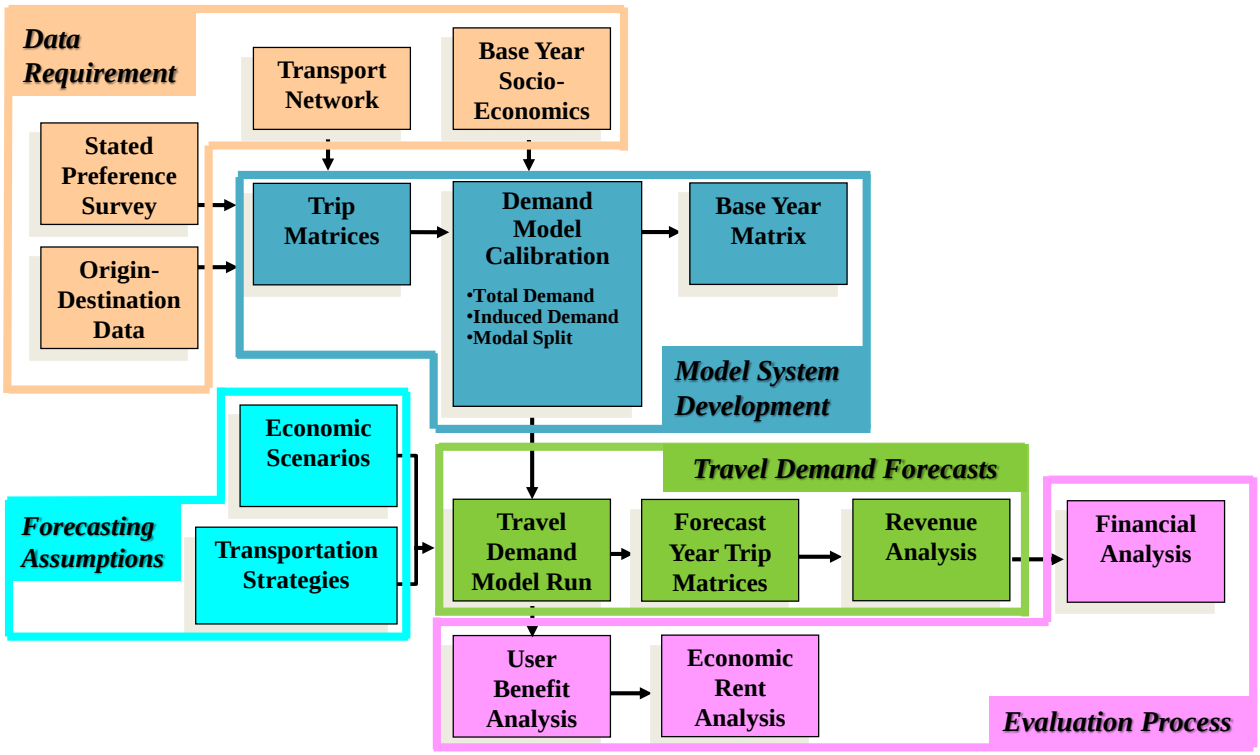
The Phase 2A report and study focused on the initial and the most vital stage of high speed passenger rail analysis: Data Collection. For high speed rail planning purposes, databases are required in four key areas:

- Market Database – Hampton Roads to Boston and Charlotte
- Technology Database – National US and International Benchmarks
- Engineering Database – Hampton Roads to Washington, D.C.
- Environmental Database –Hampton Roads to Richmond

A key driver of high speed rail studies is the Market Database. A key factor is to understand the full competitive environment for auto, air, rail and intercity bus travel between Hampton Roads and the

Northeast and Southeast corridors. Given the potential competition between the Norfolk-Richmond and Newport News-Richmond rail lines, both corridors are included in the data collection for the Market Database. As such, a thorough understanding of the responsiveness of the region's population and its opportunity to use the proposed high speed rail system provides the critical element in the ability to evaluate and potentially justify the systems. As seen in Exhibit 1-3, the final outcome of demand forecasting analysis is dependent on the socioeconomic, transportation networks, stated preference survey, and the origin destination database.

Exhibit 1-3: Market Database Requirements for *COMPASS*™ Model Ridership and Revenue Analysis

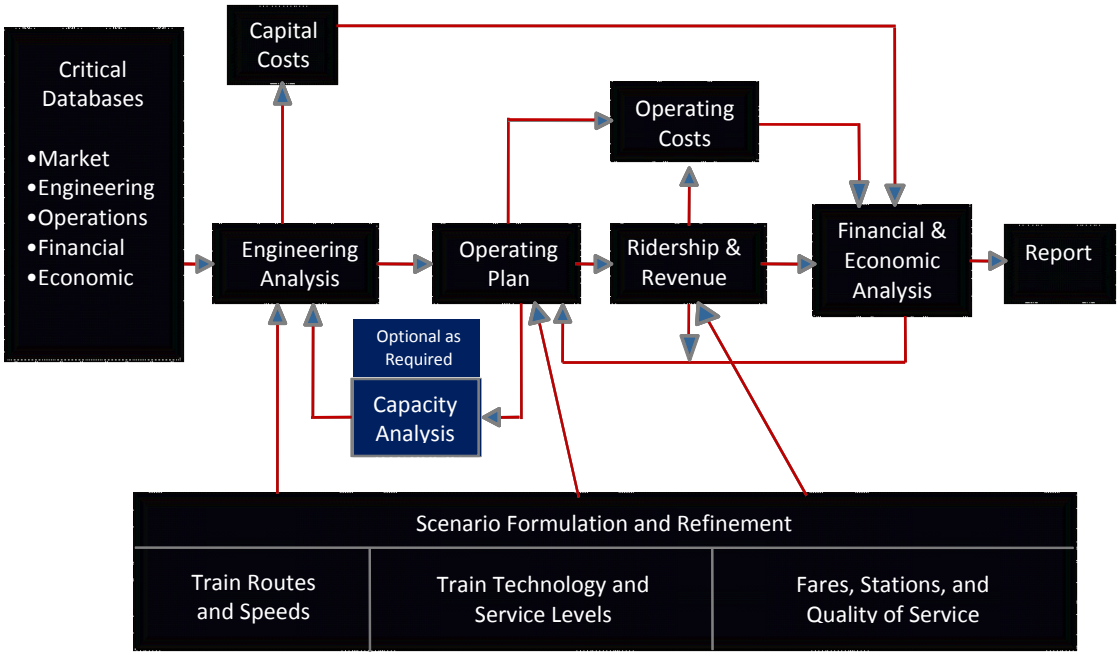


For a comprehensive travel demand model to be developed, data must be collected on the latest socioeconomic data, traffic volumes (air, bus, auto, and rail) by purpose and updated network data (e.g., gas prices) to test likely ridership response to service improvements over time. To develop ridership and revenue demand estimates, using the *COMPASS™* demand modeling system, data is needed on the quality of the service frequencies, travel times, fares, fuel prices, congestion and other trip attributes. Demand Forecasts are made by entering: long term forecasts of the economy (economic scenarios including energy prices) and future rail, and other mode strategies for infrastructure improvements, into the model in order to develop forecasts of high speed rail potential.

The second step in the process, once the existing and future market for rail travel is assessed, is an Interactive Analysis to identify (based on FRA evaluation criteria) the optimum high speed rail system for the market. Exhibit 1-4 shows the interaction of the databases and the Interactive Analysis process needed to develop the critical FRA performance metrics required to show the value of the project[1].

[1] Value of the project will be assessed by financial and economic analysis; this measures the cost benefit ratio and operating ratio.

Exhibit 1-4: Interactive Analysis Process



With respect to the quality of service offered by a high speed rail system, a detailed Interactive Analysis is needed to optimize the potential alignment and the technologies being proposed for the "higher and high speed" rail systems. To effectively model the market, the technology analysis assesses the potential technologies that will be used for both the Norfolk-Richmond and Newport News-Richmond corridors. As a result, the study investigates the interaction between alignments and technologies in order to identify optimum trade-offs between capital investments in track, signals, other infrastructure improvements, and train operating speed. The engineering assessment must include aerial and/or ground inspections of significant portions of track and potential alignments, and of potential station and maintenance base locations for each option. For the purpose of this study, TEMS *TRACKMAN™* is used to catalog the base track infrastructure and improvements, and provides a database[2] that will allow the full range of technology and train service options to be assessed. Once the track data has been collected, the *LOCOMOTION™* train performance program provides the next step in assessing the performance of various train technologies on the track at different levels of investment. The *LOCOMOTION™* program requires that different train operating characteristics (train acceleration, curving and tilt capabilities, etc.) be developed during the technology assessment.

The Technology Database will therefore need to include all the different technologies to be appraised including the existing 79-mph conventional rail, as well as the 110-mph technology associated with "higher" train speed performance and the 150 mph plus technologies associated with true high speed rail operation. The Interactive Analysis can then assess the infrastructure requirements and costs (on an itemized segment basis) necessary to achieve high levels of performance for the train technology options being evaluated.

[2] The Engineering Database includes data on existing and potential rights-of-way and alignments. The data to be assembled in TRACKMAN™ includes rights-of-way, FRA speeds, curves, speeds, grades, rail and highway crossings, signaling facilities, and potential restrictions such as bridges and track limitations. The database is upgraded by improvements to the track and signaling systems e.g., removing curves or introducing an advanced Positive Train Control (PTC) signaling system, which enforces speed limits and prevents trains from running past red signals. This allows higher train speeds and higher quality service in the corridor.

In terms of an Environmental evaluation, a Service NEPA[3] at the landscape level[4] of documentation is needed for Step 3 and Step 4. (The current Tier I EIS only covers Steps 1 and 2 phases of system development.) This includes the environmental data collection at the landscape level for the envelope of the Study Area from Richmond to Hampton Roads. This Vision Plan describes an environmental database that was prepared to support a Service NEPA Environmental Assessment. The Service NEPA is a preliminary environmental scan that leads to a decision whether a Tier 1 EIS[5], an Environmental Assessment (EA)[6], a Finding of No Significant Impact (FONSI), or a Categorical Exclusion is appropriate. This Tier 1 work may be followed by a Tier 2 EA[7] or EIS site specific analysis. Depending on the impact findings, either the EIS is prepared and followed by a ROD in case of Tiered analysis, or an FRA approval is required for a Categorical Exclusion. The process for Environmental Database collection and determining the final outcome are shown in Exhibit 1-5.

Lack of capacity and poor geometry on the Richmond to Washington D.C. segment have been reported in recent months. DRPT[8] and CSX have both indicated that the combination of freight services, Amtrak, VRE and planned SEHSR service will more than reach the capacity of a triple tracked line between Richmond and Washington. This is especially a concern if the two bottleneck areas in Ashland and Fredericksburg are not addressed and remain only double tracked. Even the DRPT planned Richmond to Washington D.C. services may face significant delays and require added schedule pad due to the lack of capacity. [9]

As a result, it is clear that development of a new greenfield alignment from Richmond to Washington D.C., and a capacity improvement plan that goes beyond DRPT's current plan, are absolute prerequisites to a potential implemention of High Speed Rail for Hampton Roads. Without an improved alignment north of Richmond, High Speed service to Hampton Roads cannot be effective. The scope of this study has not allowed a full exploration of these issues, so we can only re-state the assumptions that have been employed since 2010 in developing the operational and cost analysis. An environmental study will be required to completely confirm and validate these assumptions.

[3] Service NEPA as defined in the guidance of FRA is an essential first step for corridors providing an overview of the level of improvements that are needed to implement significantly expanded conventional or high speed rail services. This document provides an environmental database that will be used in preparation of Service NEPA Environmental Assessment for the Petersburg to Norfolk Corridor. The Service NEPA EA typically addresses the broader environmental questions relating to the type of service being proposed, Communities being served, types of operations (speed, electric, or diesel powered), ridership projections and major infrastructure components, improvement alternative being proposed and measures taken to minimize harm to the corridor. http://www.fra.dot.gov/Page/P0262

[4] Landscape level in this report refers to preliminary overview of the process i.e., inspection of an area by aerial and on site photographs without any detailed inspection.

[5] TIER 1 would be typical to large expansive projects like for example, EISs that FRA has prepared with the California High Speed Rail Authority for the state's proposed high speed rail project. http://www.fra.dot.gov/Page/P0262

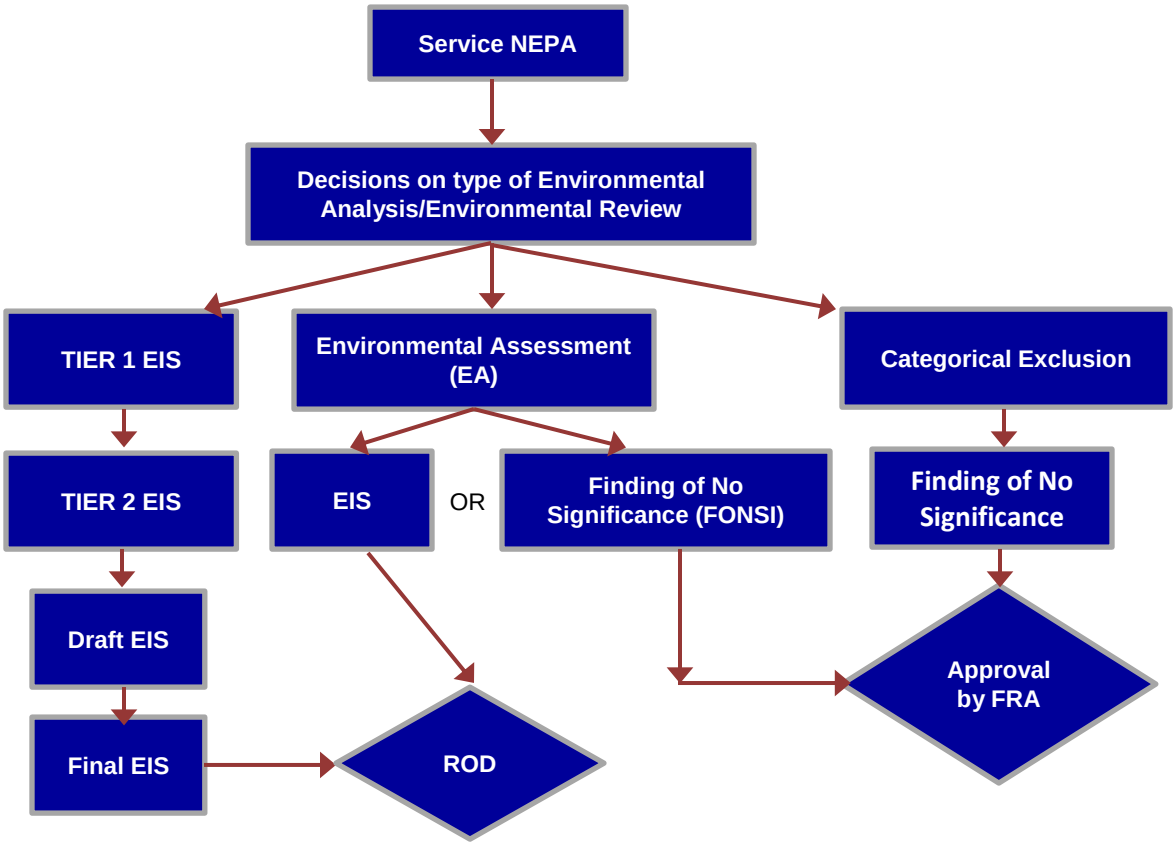
[6] An EA would be appropriate only for a more limited corridor development program where no significant environmental impacts are anticipated. http://www.fra.dot.gov/Page/P0262

[7] TIER 2 or EA would be typically for corridor programs with smaller scope and narrower range of reasonable alternatives. http://www.fra.dot.gov/Page/P0262

[8] DRPT/HRTPO meeting on October 23, 2013

[9] For example even though DRPT has suggested a 90 minute Richmond to Washington D.C. travel time might be possible, neither the SEHSR nor DRPT Hampton Roads planned service schedules are actually based on this time. Rather SEHSR and DRPT's planning both assumes a 2-hour timetable which is probably a more realistic assessment of the actual capability of CSX's alignment, even after DRPT's proposed capacity improvements have been made. See FAQ # 5 of http://www.sehsr.org/faq.html Also, the 2 hour Richmond to Washington D.C. schedule and not 90-minutes has been assumed in planning Hampton Roads service, see Table 6 of the Richmond/Hampton Roads Passenger Rail Study, Alternatives Analysis and Tier 1 Environmental Impact Statement, DRPT, November 2005 see: http://rich2hrrail.info/downloads/FinalAltDvpReport011706.pdf

Exhibit 1-5 FRA Environmental Process[10]



At this point in time, an environmental study region has been defined and preliminary environmental data has been collected. The detailed environmental work needed to precisely locate prospective alignments within the study area has yet to be completed. These will be more fully developed, with appropriate levels of community input during a future EIS if and when directed by the HRTPO

In the Phase 2B Alternatives Analysis, the market, engineering, technology and environmental data of Phase 2A was used to define the route and technology options to be evaluated.

To meet this need for the Norfolk to Richmond segment, a number of possible conceptual northern and southern options (north and south of US 460 between Suffolk and Petersburg) were defined, along with a Norfolk Southern (NS)* route that would parallel the very straight NS track (route) from Suffolk to Petersburg. The suggested three options (See Exhibits 1-6 and 1-7) are:

- A Northern Greenfield (Option 2A)
- A Southern Greenfield (Option 1A)
- A Richmond Direct (Option 3)

[10] Prepared by TEMS, based on HSIPR NEPA Guidance and Table http://www.fra.dot.gov/Page/P0262

* Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger trains utilizing it or encroaching upon it.

Exhibit 1-6: Option 2A, Northern Greenfield Route and Option 2B, Norfolk Southern Variant

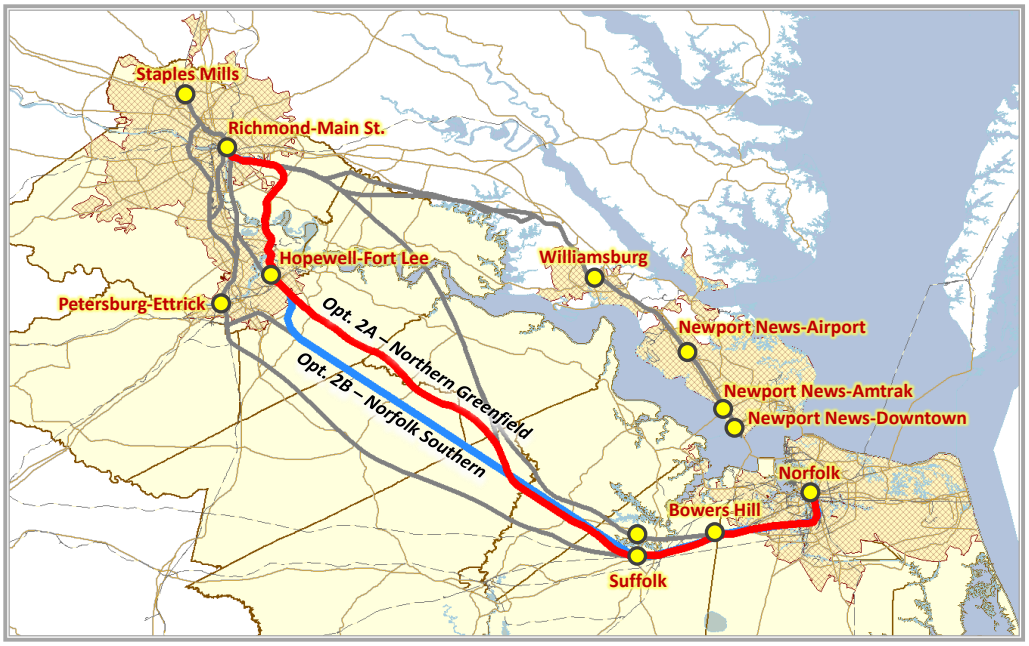
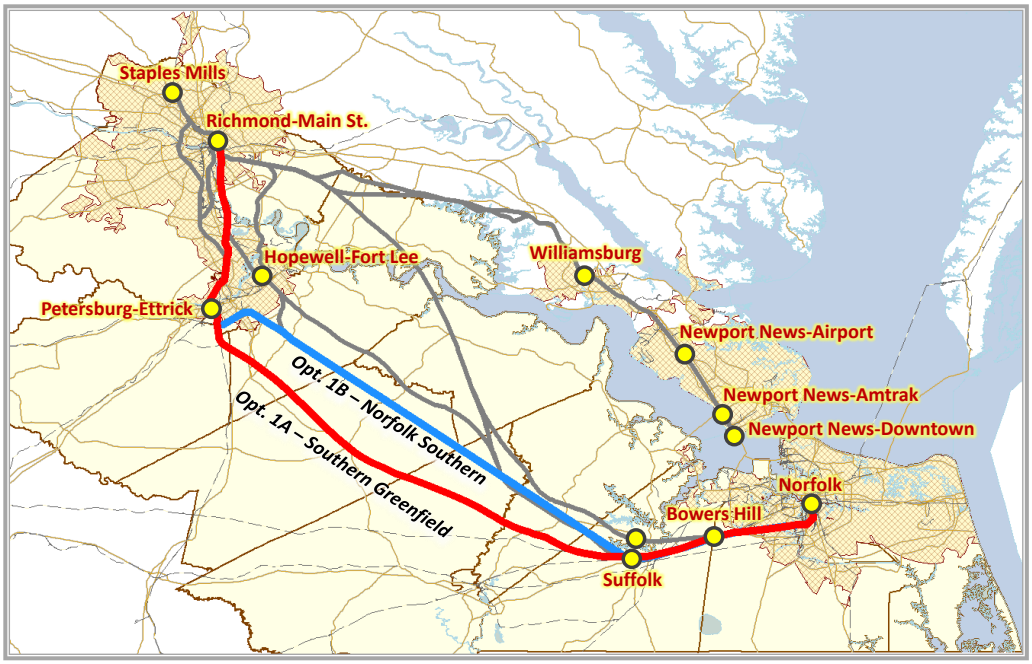


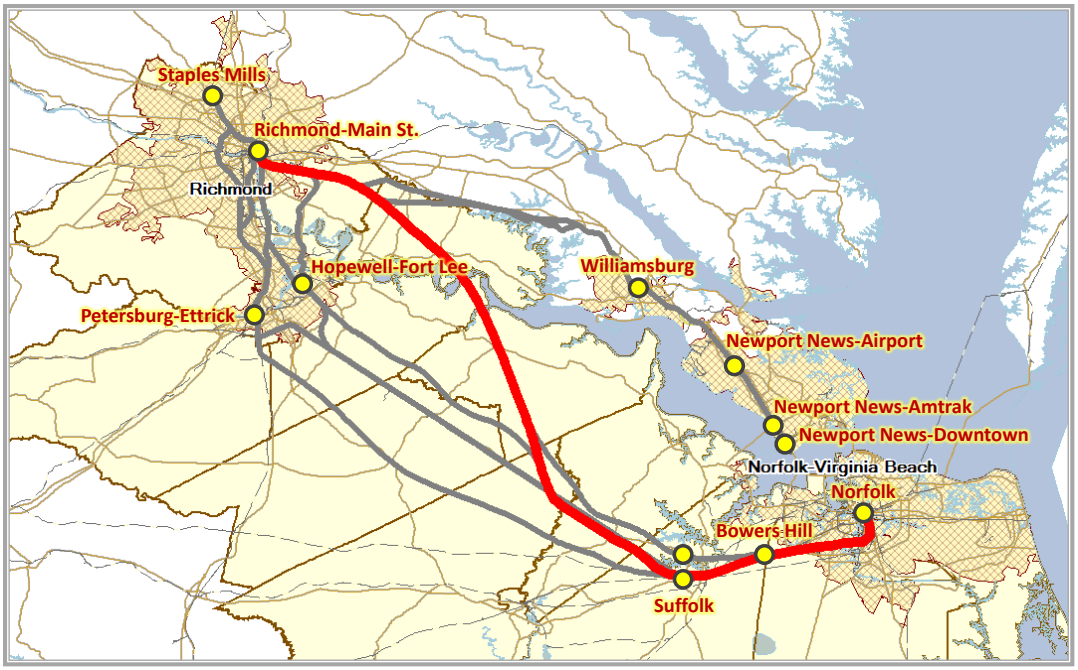
Exhibit 1-7: Option 1A, Southern Greenfield Route and Option 1B, Norfolk Southern Variant



* Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger trains utilizing it or encroaching upon it.

Environmental and engineering assumptions were developed in detail from Richmond to Hampton Roads, but all High Speed options also require a new greenfield alignment from Richmond to the Washington D.C. area. This was developed at a conceptual level in the 2010 study and has been used in the current study as a placeholder. Accordingly the previous 2010 study assumptions were carried forward into the current study. The specific assumptions made are fully described on pages B-9 and B-14 of "Progress Report B" of the 2010 Study. Subsequently, in development of the (Phase 2B) Alternatives Analysis, it became apparent that in addition to the Northern and Southern greenfield routes initially identified, a further more easterly route might be considered that gave a direct route to Richmond from Suffolk. This route was called "Richmond Direct".

Exhibit 1-8: Route Option 3, Richmond Direct



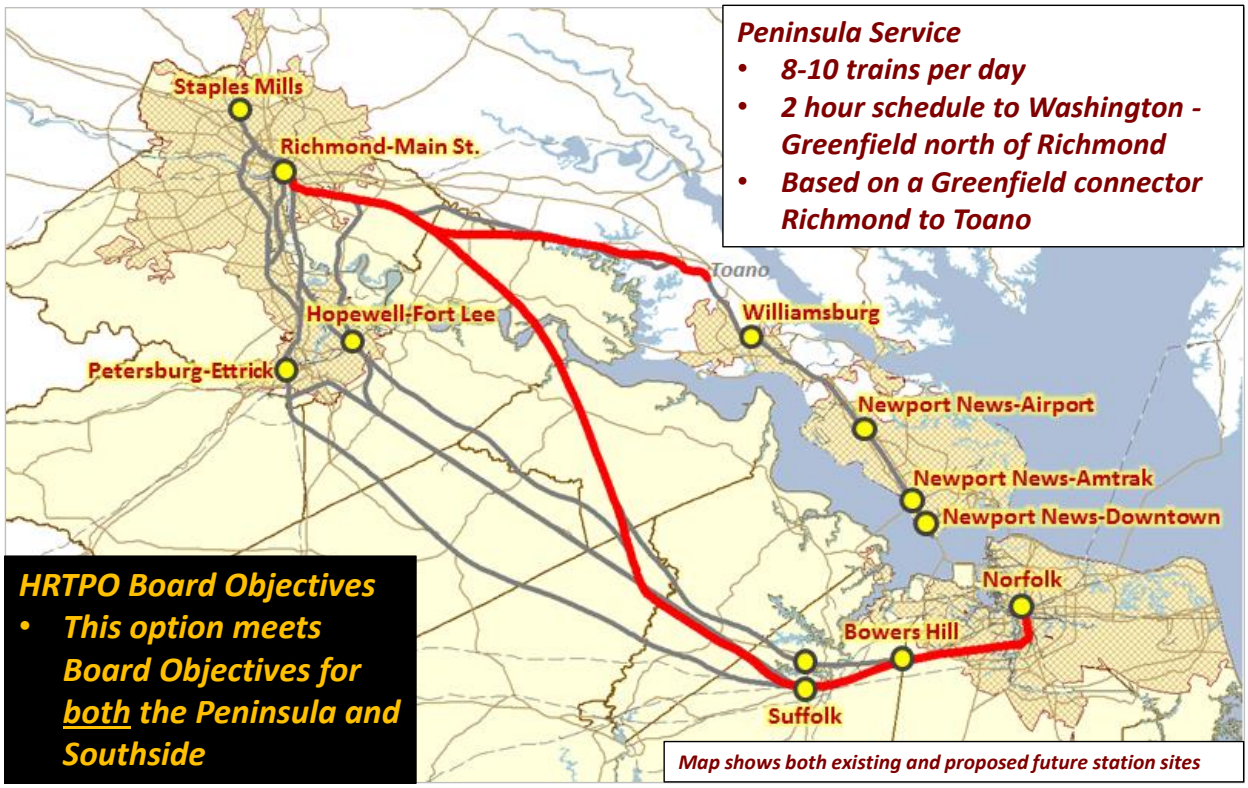
In addition to the Richmond Direct route, it quickly became apparent that it would be difficult to access Petersburg and Richmond from the south or west. As a result, a number of routes were developed that accessed Richmond from the east using suburban bypasses through Hopewell and the Richmond/Petersburg I-295 bypass. See Exhibit 1-8. This created a number of route sub options.

As a result, the Interactive Analysis suggested four main routes be assessed for developing Norfolk to Richmond connectivity; North and South Greenfield routes, Norfolk Southern* route, and a Richmond Direct Greenfield route. Beyond this however, it soon became apparent particularly that Option 3: Richmond Direct offered a synergistic opportunity to develop a Peninsula connection, so diesel trains from the Peninsula and electric trains from the Southside could share a common entryway into downtown Richmond.

This resulted in development of a new concept for adding a High Speed connection linking the Richmond Direct corridor across open countryside over to Toano. (Beyond Toano, the Peninsula through Williamsburg and down to Newport News is more heavily developed, making it harder to find feasible greenfield alignments.) It was assumed beyond Toano that diesel trains to Newport

News could enter the existing CSX tracks and that 8-10 trains per day in each direction would be operated. This was called Option 4: Richmond Direct Improved, as shown in Exhibit 1-9. Unlike Options 1-3 that only developed Norfolk service, Option 4 develops service to both the Peninsula and Southside. Option 4 is thus in compliance with HRTPO Board Resolution #2009-05 that service to both the Peninsula and Southside be developed in a balanced way.

Exhibit 1-9: Route Option 4, Richmond Direct Improved



In terms of technology, the developments in rail technology have been very rapid; and while 150 mph technology was the best commercial speed possible twenty years ago, the latest technology allows speeds up to 220-240 mph. In rural areas, Greenfield routes can be developed with only very limited curvature and are thus ideal for the highest speed trains. Since the latest 220-mph trains are similar in cost to the 150 mph trains, it was decided to assess 220-mph trains on the new Greenfield routes, and at reduced speed on track shared with freight. This 220-mph service using electric trains has been developed for the Southside.

For higher speed trains, the diesel trains capable of 110 mph can be geared to operating at 130 mph; so a new option for consideration is that of operating diesel trains at 130 mph on Greenfield routes. This 130-mph service using diesel trains has been developed for the Peninsula. In urban areas where the track is more curvy or shared with freight trains, high speed trains are limited to 79-90 mph. At the current time, Norfolk Southern allows a maximum speed of 79-mph on their right-of-way; CSX is willing to share tracks with passenger trains up to 90-mph. As a result, the planned passenger services are likely to operate in urban areas at 79-90 mph, with increased speeds of up to 130-220 mph outside the built up urban areas on Greenfield routes.

1.4 REPORT ORGANIZATION

This report is organized in the following way:

- **Chapter 1 – Introduction:** Chapter 1 discusses the purpose of the Norfolk-Richmond corridor Phase 2A Data Collection study, the Phase 2B Alternatives Analysis, the scope of the study, and the organization of the report.

- **Chapter 2 – Development of the Route and Technology Options:** This chapter describes the development of route options for analysis, including route options for accessing Richmond via Hopewell versus Petersburg or Direct approaches. Because of the identified synergy with the Peninsula a "Richmond Direct Improved" Option 4 has been developed that provides an enhanced diesel service to the Peninsula, and High Speed electric train service to the Southside.

- **Chapter 3 – Route Analysis:** This chapter identifies the speed restrictions including major speed curves, grades, major rail and highway crossings, and other potential speed restrictions and environmental issues associated with the preliminary infrastructure analysis of the existing and proposed route options. This section of the report also discusses the proposed improvements and preliminary infrastructure costs for each of the proposed route options. A detailed assessment of five Norfolk-Richmond alternatives is included, as well as a single representative route for the Newport News-Richmond segment that was necessary to complete the analysis of Option 4. An important purpose of this Chapter is to serve as a scoping document by defining a range of reasonable routes for a possible future EIS. While the current study has identified a number of potentially feasible route options, at this time, it appears that a Richmond Direct alternative offers the best approach to development of the High Speed system due to its strong synergy with the Peninsula. This finding however, still needs to be confirmed by a full environmental study.

- **Chapter 4 – Engineering Analysis:** This chapter discusses track infrastructure and train technologies, and describes unit capital costs for estimating infrastructure, equipment, and maintenance facility capital costs for each route and technology option.

- **Chapter 5 – Operating Plan and Costs:** This chapter discusses the development of the operating plan, station stopping patterns, frequencies, train times and train schedules for each route and technology option. Operating costs were also calculated for each year the system is planned to be operational using operating cost drivers such as passenger volumes, train miles, and operating hours.

- **Chapter 6 – Market Analysis:** This chapter is divided into subsections of introduction of the chapter, zone system, socioeconomic data, transportation network data, origin-destination data, stated preference survey process, results and analysis. This chapter describes the steps of developing the market data which includes developing a zone system, socioeconomic database of the Study Area, how the transportation networks were developed, how the origin and destination databases were obtained and validated, methodology used to conducting stated preference survey and analysis of the results.

- **Chapter 7 – Financial and Economic Analysis:** For each route option, a detailed financial analysis was developed, including key financial measures such as Operating Surplus and

Operating Ratio. A detailed Economic Analysis was also carried out for each route option using criteria set out by the 1997 FRA Commercial Feasibility Study and including key economic measures such as NPV Surplus and Benefit/Cost Ratio at 3% and 7% discount rates.

- **Chapter 8 – Preferred Option Development:** This chapter will assess the impact of integrating the Norfolk and Newport News – Richmond options assessed in Chapter 7, with the Southeast High-Speed Rail and further develop the potential synergies between the two services.

- **Chapter 9 – Conclusions:** This chapter outlines the key findings of the study, and the next steps that should be taken to move the project forward.

- **Appendices:**
  - Appendix A – Zone System and Socioeconomic Data
  - Appendix B – *COMPASS*™ Model
  - Appendix C – *TRACKMAN™* Files
  - Appendix D –Environmental Scan Updated
  - Appendix E – Phase 2(A) Engineering Field Survey: Petersburg to Norfolk
  - Appendix F – Transportation Use of Utility Corridors Reference
  - Appendix G – 1993 Peninsula Route Assessment by D. W. Dodson
  - Appendix H – Public Comments

2. DEVELOPMENT OF THE ROUTE AND TECHNOLOGY OPTIONS

For implementation of high speed rail service in the Hampton Roads to Washington corridor, a Tier 1 Alternatives Analysis and Environmental Study will be needed to determine the most appropriate and effective greenfield alignment option. This Vision Plan and Environmental Scan are needed to serve as an essential but preliminary Scoping Study for developing the options and estimating the level of effort that will be needed to complete a full environmental analysis. In recent years, inclusion of an Environmental Scan as part of the route and technology evaluation has increasingly become a standard component of rail corridor feasibility studies. This is especially true for high speed studies like this one, which propose to develop extensive segments of new Greenfield alignment. This chapter first covers the requirement for developing the environmental database and definition of the National Environmental Policy Act (NEPA); second, the list of databases such as geographic boundaries, cultural resources, ecology, hazardous material sites, and air quality in the proposed environmental study area; third, the Route Options; and finally, the Train Technology Options.

2.1 PURPOSE OF THE ENVIRONMENTAL ANALYSIS

In developing route options for the study, an initial overview of environmental issues is considered a critical element of National Environmental Policy Act (NEPA) compliance for the development of high speed passenger rail service. Under the Federal Railroad Administration's (FRA) HSIPR program guidance, FRA implements the environmental review process as required by the National Environmental Policy Act (NEPA) together with related laws and regulations, (including Section 106 of the National Historic Preservation Act and 49 U.S.C. 303, which protects public parks, recreation areas, wildlife and waterfowl refuges, and historic sites). The statutory requirement as stated in the *HSIPR NEPA Guidance*[1] is that "NEPA requires that appropriate environmental documentation be available to public officials and citizens *before* decisions are made and actions are taken. *The available information should be relevant to the decision to be made at any particular stage of project development*" (italics added for emphasis) including the decision as to whether or not to launch a detailed environmental study in the first place.

To apply for funding for a high speed rail system, FRA has defined the creation of a Service Development Plan (SDP) as well as a Service NEPA as essential first steps. *It is important to note that neither the "Service NEPA" nor SDP are actually NEPA legal documents; they are only support for an FRA funding application.* A "Service NEPA" has been defined by the FRA as a *landscape level of environmental review that defines from day one the most critical environmental issues before any substantial investments in the corridor are made.* The reason for developing a Service NEPA is to ensure that there are no *obvious* fatal flaws associated with the proposals being submitted to the FRA, and that due diligence and reasonable consideration have been given to the environmental issues associated with the project.

The *HSIPR NEPA Guidance* states that "Several different approaches are available to accomplish Service NEPA," including for advanced projects, "Tiered NEPA (Tier 1 environmental impact statement (EIS) or environmental assessment (EA) followed by Tier 2 EISs, EAs or categorical exclusion determinations (CE)) or non-Tiered NEPA (one EIS or EA covering both service issues and individual project components)"[1]. A large expansive project such as a high speed rail corridor development would typically be addressed in a Tier 1/2 EIS process requiring several rounds of environmental review, such as the multiple EIS's that have been prepared by the California High-Speed Rail Authority, and the Georgia and North Carolina Departments of Transportation. However, it is clear that SDP's and Service NEPA's can only be developed to a level of detail reflecting the stage of development of each project. As projects advance, more detail is needed to support the progressively increasing funding amounts required. Clearly

[1] Compliance With The National Environmental Policy Act In Implementing the High Speed Rail Intercity Passenger Rail Program, August 2009. https://www.fra.dot.gov/Elib/Document/2319

a Service NEPA associated with a construction application will have more detail than one associated with an application for EIS Tier 1 funds.

This chapter and Appendices D and E, present a high level Environmental Scan that is intended to give insight into the issues that may be associated with a decision to proceed with further development of the High Speed rail system. An initial "Service NEPA" at this stage should consist of a mapping analysis of environmental factors within the corridors where proposed alignments are likely to be located. A preliminary conceptual analysis is sufficient to show that there are no obvious fatal flaws along the routes that might be developed. Where environmental issues do arise, there should be an understanding of potential mitigation or avoidance strategies. This level of environmental planning ensures that the routes proposed for a Tier 1 EIS are in fact "Reasonable Routes" and that they are likely able to be developed into fully engineered alternatives. Clearly, detailed development of such routes will be part of the Tier 1/2 EIS. Any representative alignments used as the basis of the analysis are highly conceptual and preliminary. The primary reason for considering environmental issues along the corridors is to identify (and avoid) *obvious* fatal flaws, and to develop an order-of-magnitude assessment of potential impacts.

It is expected that this Environmental Scan can serve as a very useful tool for agency outreach to engage discussion, and gain FRA concurrence on the list of reasonable routes that may need to be screened in a potential future Tier I EIS. For doing this, it is essential to identify both the number of alternatives that need to be assessed, and to assess the level of detail at which they will likely need to be evaluated to support a screening determination. This is essential so that the Service NEPA can support the funding application and also aid in planning the actual Tier 1 EIS, including estimating of the level of effort that will likely be needed to complete it. This document therefore, serves as the "bridge" between preliminary Feasibility-level planning and the formal NEPA environmental documentation which is still to come if development of the High Speed rail system is going to be further pursued.

2.2 LIST OF DATA COLLECTION AND MAPPING SOURCES

This section identifies the potential list of factors that impact on the community and environment to include transportation, air quality, noise and vibration, energy, land use, socioeconomic factors, community impacts, environmental justice, parklands, farmlands, aesthetics, utilities, contaminated sites, cultural resources, geologic resources, hydrologic and water resources, wetlands, and biological resources (habitats and species). Potential environmental constraints will be reported in the next phase of the study based on the proposed alternatives. A more detailed environmental analysis will be needed once preferred alternatives are assessed in the Tier 1/EA analysis. Exhibit 2-1 provides an overview of the list of data collection elements that will be discussed in the following report sections and in Appendix D, which provides an update to the environmental scan level data presented in the "*Hampton Roads Passenger Rail Study Data Collection – Phase 2A Norfolk – Hampton Roads Corridor*" report submitted by TEMS in March 2013. The following sources provided significant input to the development of this chapter and Appendix D:

- NEPA Guidance: Compliance with the National Environmental Policy Act in Implementing the High-Speed Intercity Passenger Rail Program.
- Service NEPA Environmental Assessment Chicago-Detroit/Pontiac Rail Corridor Improvements From Chicago, Illinois to Pontiac, Michigan by Michigan DOT.
- Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, Virginia DRPT.
- Passenger Rail Investment and Improvement Act of 2008 (PRIIA).

Exhibit 2-1: List of Elements and Data Sources

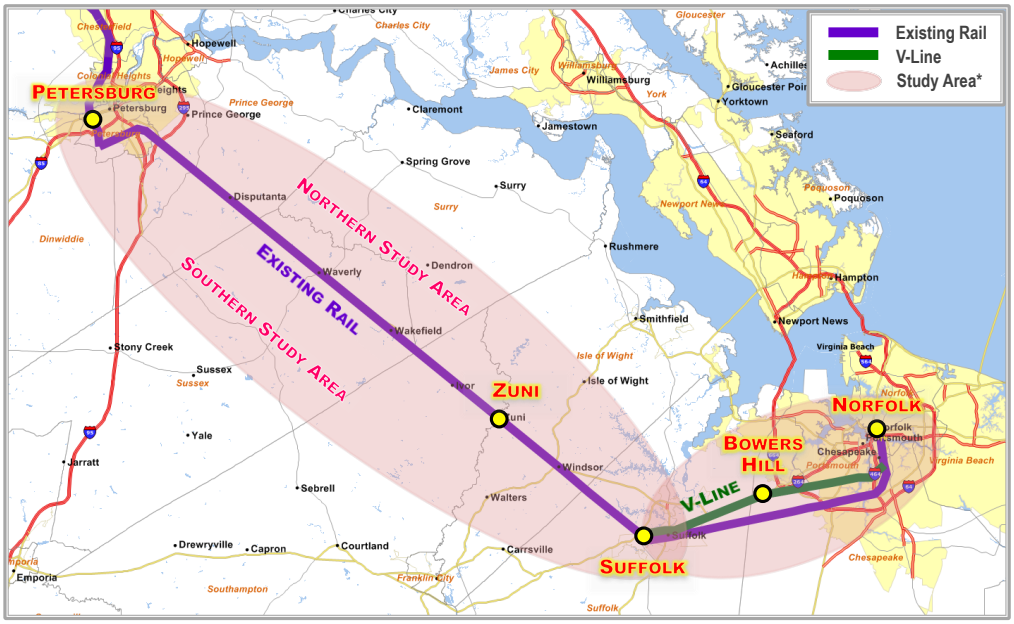
Data Element	Source
Geographic Boundaries: State, County, Census tract, Census Block Group, City, MPO, MSA, Congressional Districts, Community Facilities	US Census Bureau: 2009 TIGER/ Line Shapefiles and Virginia Department GIS, National Transportation Atlas Database (NTAD)
Cultural Resources: Parks, Wildlife Refuge, Heritage preserves, Archaeology resources, Historical resources, Federal lands, etc.	Virginia Department of Conservation and Recreation (DCR), United States Department of Agriculture Forest Service National Park Service U.S. Department of the Interior U.S. Fish and Wild life Service VA DCR: Natural Heritage site Virginia Department of Forestry
Ecology: Wetlands, Hydric Soils, Streams, Waters of US, State waters, Federally protected species, State protected Species, Critical stream habitats, Migratory bird habitat, floodplain encroachment/impacts, coastal zone encroachments	Virginia Department of Game and Inland Fisheries, National Wetlands Inventory, US Fish & Wildlife Service, Virginia Department of Conservation and Recreation: Land Conservation Data Explorer, VA Natural Landscape Assessment (VaNLA)
Hazardous Materials	Virginia Department of Environmental Quality, US EPA
Air Quality	Environmental Protection Agency
OTHER (Satellite Imagery, Street Views, Land Parcel Data, etc.)	Google Earth, Bing Maps, Henrico Co. Parcel Viewer, Richmond Parcel Mapper.
Noise and Vibration,	*High-Speed Ground Transportation Noise and Vibration Impact Assessment*, U.S. Department of Transportation, Federal Railroad Administration, Washington, DC, December 1998 standards, and Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, Virginia DRPT.
Utilities,	Aerial photographs and mapping available from several internet sites (Google Earth, Bing Maps) site specific photographs, and Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, and Virginia DRPT.
Environmental Justice,	U.S. Census
Geology and Soil,	U.S. Geological Survey (USGS) maps, Virginia Department of Conservation and Recreation: Land Conservation Data Explorer.
Transportation,	U.S. Census, National Transportation Atlas Database (NTAD)
Land Status, land Use, and Zoning,	U.S. Census, Henrico County Parcel Viewer, Richmond Parcel Mapper (Zoning-City of Richmond)

Socioeconomic Conditions, and	U.S. Census
Public Health and Safety: Railroads grade crossings, Pedestrians and Rail operations	Federal Highway Railroad (FRA) and Federal Highway Administration (FHWA)

2.3 ENVIRONMENTAL STUDY AREA

The Environmental Study Area is defined by the potential region or area within which potential rail alignments might lie and for which environmental data must be collected. For the preliminary step of data collection in Phase 2(A), an environmental study area from Norfolk to Petersburg was defined and landscape environmental data such as cultural resources, ecology, hazardous materials, air quality, noise and vibration, utilities were collected at a landscape level.

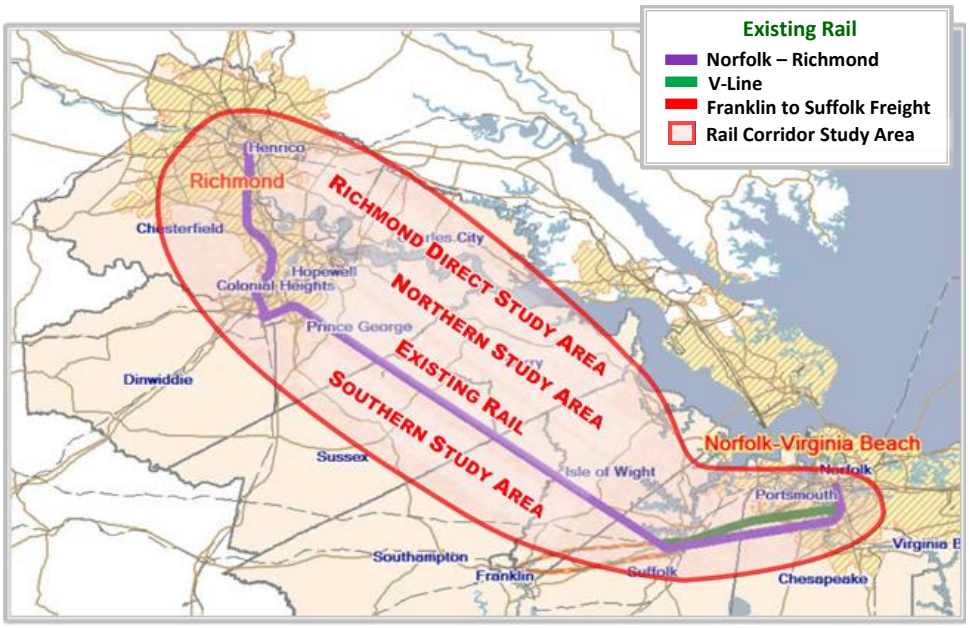
Exhibit 2-2: Original Environmental Study Area* – Phase 2(A) Study



In the Phase 2(B) study, the environmental study area had to be expanded to allow for development of the "Richmond Direct (Option 3)" route as described in Chapter 1. The environmental study area was extended from Hampton Roads to Richmond, VA and data collection and the resulting tabulations in *Appendix D: Environmental Scan (Updated)* were updated. Exhibit 2-3 shows the expanded environmental study area that was used in the original Phase 2(B) study[2]. For assessing the feasibility of High Speed rail service from Norfolk to Richmond, multiple route options were developed at the feasibility level within this study area. The results given in Appendix D are based on this area.

[2] U.S. Census and 2009 TIGER/Line shapefiles provide information on state, county, city, and MPO boundaries for the State of Virginia and these sources were used in specifying boundaries for the Norfolk to Richmond Environmental Study Area. The counties and independent cities considered in the Norfolk to Richmond Study Area are as follows: Henrico Co., Chesterfield Co., Richmond City, Charles City Co., Colonial Heights (city), Hopewell (city), Petersburg (city), Prince George Co., Dinwiddie Co., Surry Co., Sussex Co., Isle of Wight Co., Southampton Co., Franklin (city), Suffolk (city), Portsmouth (city), Norfolk (city), Chesapeake (city), and Virginia Beach (city). This study area was taken as the base for preparing all environmental database maps for the Phase 2B Study.

Exhibit 2-3: Norfolk to Richmond Environmental Study Area (Original Phase 2B)



Subsequently HRTPO Supplemented Phase 2(B) to fully assess "Richmond Direct Improved (Option 4)." This was originally developed only as a sensitivity option in the original Phase 2(B) study, but HRTPO asked for a higher level of certainty on the Capital Costs in the draft report, adding Option 4 for providing enhanced passenger rail to the Peninsula[3]. The previously approved Phase 2(B) report and the Supplemental work for the Peninsula were combined together to complete the Hampton Roads High Speed Passenger Rail Vision Plan Alternatives Analysis.

It should be noted that a number of potentially viable routes have been identified for each segment, but only one representative Peninsula route has been developed here. Additional alternatives are suggested for scoping the Tier I EIS. As a result, we do not claim that the representative route is optimal[4] or that it will ultimately be selected by the environmental analysis. If other routes turned out to be better than the one suggested, then the current study assumptions would be conservative. This is appropriate for the current stage of project development, and is sufficient for confirming the capital costs.

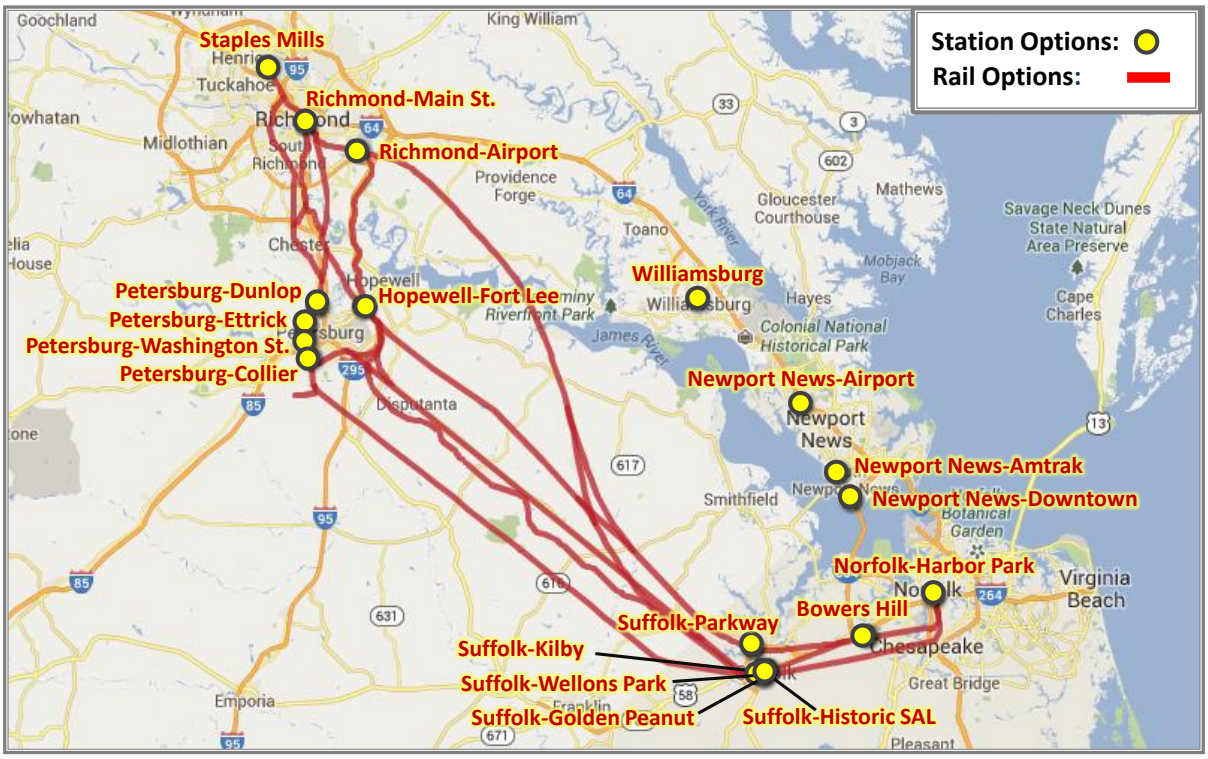
[3] It should be noted that the original Phase 2(B) capital costs had $0 for the Peninsula (due to the initially restricted Scope of Work) and that Washington D.C. to Richmond costs were scaled from the earlier 2010 Vision Plan, brought to current dollars. Those 2010 costs had been benchmarked on the basis of similar greenfield routes but without the benefit of route specific analysis. To bring the Peninsula capital costs up to a Feasibility level required a fundamental reexamination and refinement of the assumptions that had been made by the 2010 study.
[4] Such a determination would require much more detailed environmental study and the development of a full alternatives analysis, which would be performed during the Tier I EIS evaluation.

2.4 ROUTE OPTIONS

2.4.1 Potential Route Options from Norfolk to Richmond

The route options from Norfolk to Richmond are derived from the Phase 2(B) assessment. From Norfolk Harbor Park station to the proposed Portsmouth suburban station at Bowers Hill, all options share a common routing over the Norfolk Southern "V"-Line. Alignment options west of Bowers Hill include the possibility of adding track to the existing NS* rail corridor, as well as potential Northern, Southern, and Richmond Direct greenfield options[5,6]. Exhibit 2-5 shows all the route and station options that were initially considered for the Norfolk to Richmond segment. Some options were screened early on, while the surviving options were defined to a greater level of detail.

Exhibit 2-5: Potential Rail Routes* in the Norfolk to Richmond Corridor



Alignments will not be determined until the Tier II Environmental Process is complete.

*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

[5] A Greenfield is a brand-new proposed rail line where no rail line ever has existed. This contrasts with upgrades to an existing rail corridor, or the restoration of an abandoned rail corridor, since the locations of existing or abandoned alignments are known for sure. We have identified potential corridors for conceptual Greenfield options both north and south of the existing NS rail line, but have not located the alignments precisely.

[6] This follows the approach of the US 460 highway study, which in addition to assessing the possibility for improving the existing US 460 highway, also developed one greenfield option north, and one greenfield option south of the existing highway. This level of environmental assessment was considered adequate for locating a new highway and resulted in a Record of Decision, so it was thought that it should be appropriate for locating the rail line as well. However, one additional option (Richmond Direct) has been refined and developed based on feedback received through the stakeholder involvement process.

From Petersburg to Richmond, Southeast High-Speed Rail (SEHSR) currently plans to add one additional track following the CSX existing "S-Line" rail corridor into Richmond. The current Amtrak "A Line" routing from Petersburg directly to Staples Mill was not considered for this study, since it bypasses downtown Richmond. Adding Norfolk trains to the already planned service using the "S-Line" may necessitate adding a second additional track to at least parts of that alignment. Since this option has already been well-studied in the SEHSR process, it was not assessed in detail here; but, the current SEHSR plan does allow room for an additional track to be added. Based on stakeholder advice, it is believed that the incremental environmental impacts of doing this would be minimal beyond those impacts that have already been identified for the basic SEHSR improvements. If it were decided to carry this option forward in a Tier 1 NEPA evaluation it would be necessary to coordinate the impacts of adding a Norfolk service with the SEHSR environmental process. However, following SEHSR into Richmond would limit speeds to 90 mph all the way from Petersburg to Richmond; and as such, would not allow true high speed service.

Possible rail use of the proposed new US 460 highway corridor, also shown in Exhibit 2-5, was considered. Unfortunately, the curves along the proposed new US 460 are too sharp for passenger trains to effectively use the alignment. Conversely, the grades are too steep for freight trains, particularly at certain highway interchanges where the freeway is planned to overpass local roads. The geometric requirements for adding a freight track could not be accommodated without redesigning those interchanges to reduce grades, by taking local roads over the freeway. As a result, the alternative of using the US 460 highway alignment for either freight or passenger rail was not considered further.

The focus of the current study has been to identify options that could allow for truly high speed (125 mph or greater) service except in densely built up urban areas, where the need to share existing rights of way[7] is likely to constrain speed. Three main route options have been developed utilizing a combination of greenfield and existing rail rights of way: via Petersburg, Hopewell and Richmond Direct.

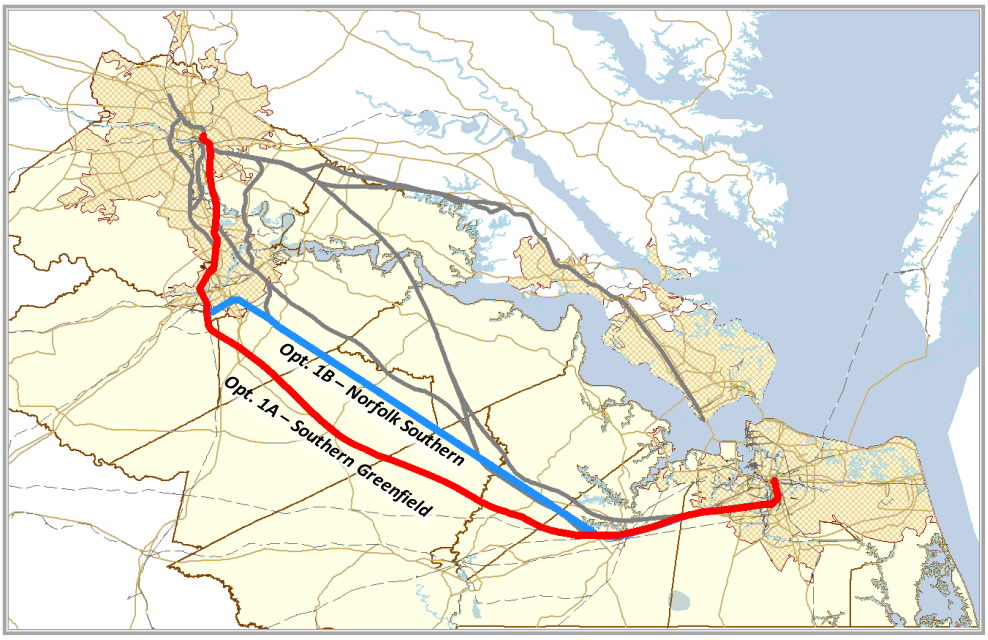
For the Petersburg and Hopewell options, variants have also been developed based on the existing NS rail corridor. Normally, geometric issues would prevent a true high speed service operating along an existing rail alignment, but in this highly unusual situation the existing alignment is arrow-straight from Suffolk to the outskirts of Petersburg. This suggests at least the possibility of developing a high speed service within or close to this right-of-way, in concurrence with NS policy, so a preliminary assessment has been performed.

Southern Option 1 via Petersburg: As shown in Exhibit 2-6, two route variants were developed from Norfolk to Richmond via Petersburg. Option 1A, a ***Southern Greenfield,*** was developed that could use a portion of the abandoned "Virginian" right-of-way from Suffolk west to the vicinity of Walters, VA, where it would turn northwesterly on new alignment to Petersburg[8]. Option 1B is based on the existing Norfolk Southern rail alignment from Suffolk to Petersburg (Collier). For linking the NS Option 1B over to Petersburg, at Poe there is a need to grade separate both the NS Main Line rail crossing as well as I-295. Implementing this grade separation would likely require either a tunnel or a high level bridge. Continuing from Poe to Collier, residential and commercial development encroaches tightly on the Petersburg Belt line right-of-way; so significant property taking might be needed to widen the corridor. North of Petersburg to Richmond, a high speed option was developed to improve geometry compared to the existing CSX rail corridor. An East Shore Greenfield would leave the CSX corridor north of Dunlop, parallel I-95 for a short distance

[7] This is characteristic of California's "Blended" approach http://www.caltrain.com/projectsplans/CaltrainModernization/BlendedSystem.html which has also been typical of the way European high speed systems have been developed, by following existing rail alignments into urban areas.
[8] However, the Country Club of Petersburg and Richard Bland College were seen to both lie across the path of a direct rail alignment. This particular conflict could be eliminated by shifting the option farther south to Burgess. It must be emphasized however, that this Southern routing has not been precisely located. The current analysis only suggests that it may be possible to avoid some obvious obstacles south of the existing rail alignment. It does not suggest any precise location for the alignment.

and then cross to the east shore of the James River in the vicinity of Osborne Landing. From there, it would traverse relatively undeveloped farmland on the east shore of the James River, skirting but not directly impacting the Richmond National Battlefield Park, and then rejoin the CSX existing rail alignment (Peninsula Subdivision) in the vicinity of the Fulton Gas Works. From here, the alignment would fly over the CSX tracks to the north side, and approach Richmond Main Street station from the east, rather than from the south. Conceptually, the SEHSR could also choose to share the East Shore Greenfield in lieu of developing the currently planned "S"-Line approach via Centralia.

Exhibit 2-6: Petersburg Rail Options 1A and 1B

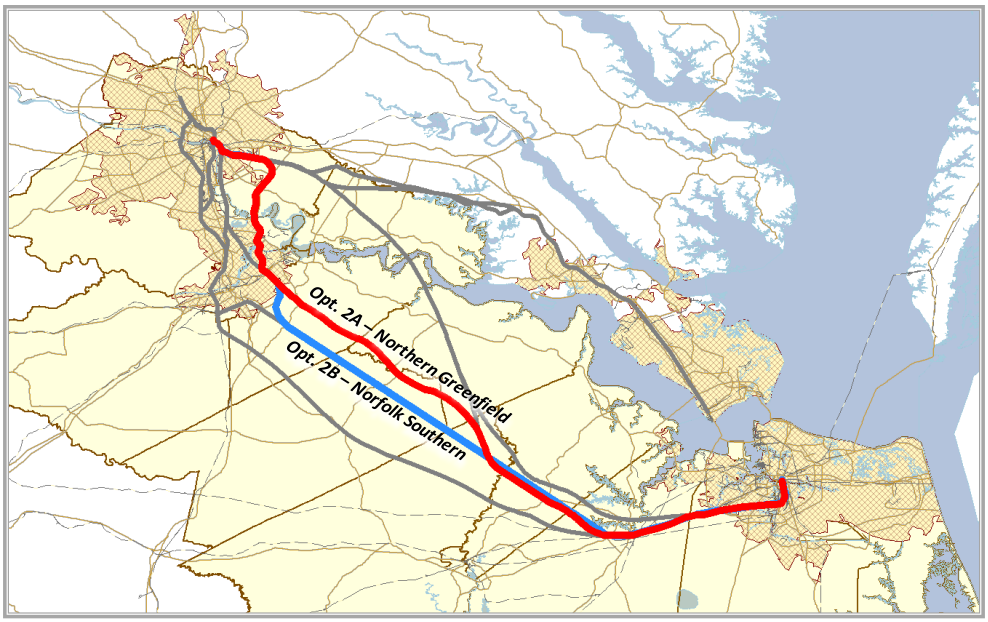


- **Northern Option 2 via Hopewell:** As shown in Exhibit 2-7 two route variants were developed from Norfolk to Richmond via Hopewell. Option 2A, a ***Northern Greenfield,*** was developed that would enter the I-295 median south of Fort Lee.[9]. Option 2B is based on the existing Norfolk Southern* rail alignment from Suffolk to Petersburg (Poe). Option 2B would connect to I-295 where the railroad alignment passes under I-295 on the east side of Petersburg.

  From Fort Lee north, it appears that the most practical approach would be to follow I-295 north to where it crosses the CSX Peninsula Subdivision line just east of Richmond Airport. The option would then parallel the CSX Peninsula Subdivision on the north side into downtown Richmond. The alignment would also approach Richmond Main Street station from the east, rather than from the south. Conceptually, the SEHSR could also share this alternative by constructing a connecting greenfield from Burgess to the junction of I-95 and I-295, then following the I-295 median north.

[9] Since most of the Norfolk ridership will be headed north towards Richmond and Washington D.C., a northerly alignment would tend to be shorter and more direct. From Suffolk to Zuni, a new rail alignment could either parallel the existing NS rail line or follow an existing electric utility right-of-way. Beyond Zuni the proposed alignment would cross to the north side of the existing rail alignment and head towards Prince George, VA. The Northern Greenfield would line up with I-295 and follow the highway past Fort Lee. A challenge to the development of any northerly option is how to get through the heavily built-up urban area which covers the whole area from Petersburg to Hopewell on the west shore of James River. However, the I-295 median could provide a possible alternative passageway through the area.
*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

Exhibit 2-7: Hopewell Rail Options 2A and 2B



As a result, it can be seen that the Southern Greenfield is logically paired with the East Shore Greenfield in Option 1; while the Northern Greenfield is paired with I-295 in Option 2. The Norfolk Southern* variant[10] could pair with either the East Shore Greenfield (via Petersburg) or I-295 (via Hopewell) north to Richmond.

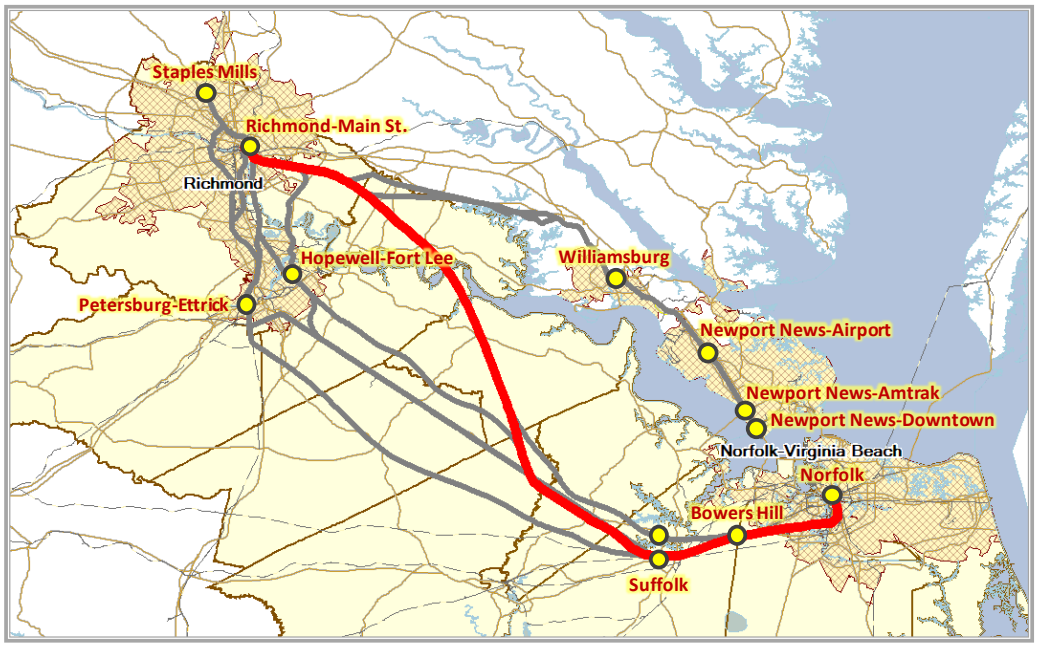
The possibility of constructing a hybrid option "1/2" by pairing the Northern Greenfield with the East Shore Greenfield was considered. Making this connection would require construction of a high speed rail alignment directly across the Fort Lee grounds, which are used for active military training. It is not clear that crossing Fort Lee is even feasible, and a preliminary review of this option does not show any clear environmental or operational advantages to doing this. Adding this option into the study would only appear to make sense if some fatal flaw were found in the I-295 opportunity. Given the difficulties associated with crossing the Fort Lee grounds, it is likely that this hybrid option of linking the Northern Greenfield to the East Shore Greenfield will be screened early in the Tier 1 NEPA evaluation.

- **Option 3 – Richmond Direct:** shown in Exhibit 2-8 foregoes the benefit of serving intermediate markets at Petersburg and Hopewell, but it also avoids the high costs and environmental issues associated with developing urban infrastructure and sharing either the SEHSR (CSX rail) or I-295 (highway) alignments through Petersburg or Hopewell. The ***Richmond Direct*** option instead relies on the planned SEHSR service to serve Petersburg. Bypassing this area with its potentially high development cost could potentially offer the fastest, most direct and most cost effective way to connect south Hampton Roads to Richmond and the large cities of the Northeast Corridor.

[10] From Suffolk to Petersburg, a Norfolk Southern variant of Options 1 and 2 was considered. The key element of this analysis was a sensitivity analysis of the adoption of various corridor widths or "footprints" for adding passenger tracks to the existing rail corridor. This suggested the technical possibility of squeezing up to four tracks within a 100' wide right-of-way, with a 30' minimum separation between active freight and passenger tracks, or a 120' wide right-of-way with a 50' minimum separation. A key finding was that footprints wider than 120' would result in excessive property taking and significant wetland impacts. These would produce an uncompetitive environmental profile as compared to available greenfield options. As a result it is not likely that any "wide footprint" options will survive preliminary screening in a NEPA evaluation. However, the analysis also suggests that a "tight footprint" option up to 120 feet wide for the NS existing rail corridor could produce an environmental profile that is competitive to greenfield alternatives, so this option was retained.
*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

Doing this also maximizes potential synergies with development of Peninsula service to Newport News, which could utilize the high speed alignment for access to downtown Richmond.

Exhibit 2-8: Option 3 - Richmond Direct



From Suffolk to Zuni, the representative alignment would follow the same route as the Northern Greenfield: a new rail alignment could either parallel the existing NS rail line or follow an existing electric utility right-of-way[11]. Beyond Zuni the alignment would cross to the north side of the existing rail alignment and head straight towards Richmond. Crossing the James River in the vicinity of Charles City, the alignment would gently curve west to line up with the CSX Peninsula subdivision east of Richmond Airport. From here, crossing under I-295 and paralleling the CSX Peninsula Subdivision on the north side into downtown Richmond, the alignment would approach Richmond Main Street station from the east, rather than from the south.

The possibility of adding intermediate station stops to serve local communities between Suffolk and Richmond has also been noted. The High Speed service is planning to run enough trains so some trains could stop in Surry County[12] (pop 7,828) and Charles City County[13] (pop 7,256) without harming the overall service objective for the system. Surry County in particular has requested consideration of an added stop. The Surry County Comprehensive Plan identifies only three economic centers: Claremont, Surry and Dendron; of these, the county land use plan suggests that Dendron[14] should become the focus of future Surry County economic development

[11] As part of the Richmond Direct or Northern Greenfield options, a possible alternative around the north side of Suffolk was also considered. Heading west from the proposed Bowers Hill rail station, instead of following the CSX Portsmouth Subdivision into downtown Suffolk, a "Suffolk Bypass" would head straight west across the Dismal Swamp, skirt the Suffolk Regional Landfill and follow US-13 around the northern outskirts of Suffolk. This is attractive because it could potentially allow an electric train to accelerate directly to 220-mph upon leaving the Bowers Hill station. However, because of extensive wetland impacts and to avoid significant property taking, it is likely that a significant portion of this alignment would need to be constructed on elevated structure. Stakeholders did not consider it to be fatally flawed, but an alternative utilizing the CSX Portsmouth Subdivision through downtown Suffolk will likely be much more cost effective. It is expected that the Suffolk Bypass will likely be screened early on in a Tier I NEPA evaluation because of right-of-way issues, wetland impacts and the high cost of the elevated structures that will likely be required.

[12] See: http://en.wikipedia.org/wiki/Surry_County,_Virginia

[13] See: http://en.wikipedia.org/wiki/Charles_City_County,_Virginia

[14] See: http://www.surrycountyva.gov/uploads/docs/COMPREHENSIVE%20PLAN%20PART%20B.pdf, p. 64. *The town of Dendron is in close proximity to U.S. Route 460 and the Norfolk Southern Rail Line. Dendron will be connected to the Surry County waste water treatment plant in the near future. With the development of a water system, the necessary utilities to permit urban growth will be in place, and Surry County can compete for the economic growth that will be stimulated by the multi-modal transportation development on the county's southern border.*

efforts. In Charles City County, the proposed Richmond Direct alignment passes within a mile of the county seat, making Charles City a logical stopping place north of the James River.

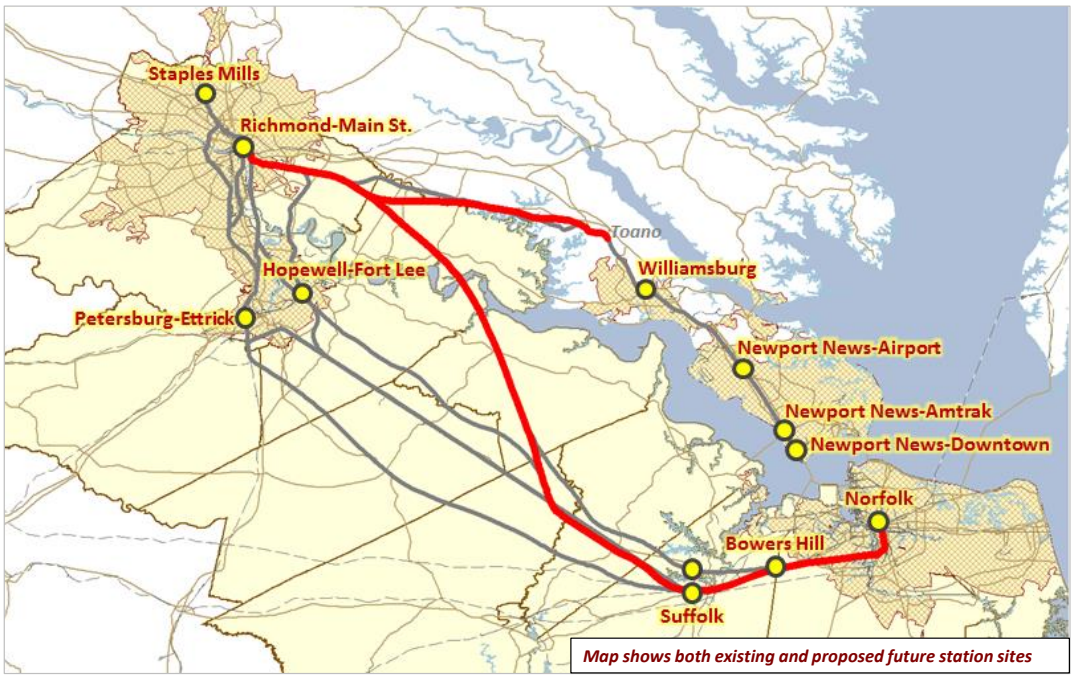
Given the current low population of these two counties, stops at Dendron or Charles City have not been shown on the station map in Exhibits 2-5 or 2-8. Presently, adding these stations would not materially impact the ridership forecast, financial or economic projections for the High Speed rail system. If stops were added however, the high speed rail system could contribute significantly to the economic growth of these two counties. Over time as economic growth induces more ridership, these stations might start contributing more significantly to the ridership, financial and economic case for developing the High Speed rail system. The prospects for adding these stations should be assessed more thoroughly in the proposed Tier I EIS.

Please note that these options are more fully developed in Chapter 3. In addition, Appendices D and E contain additional detailed information that is specific to the Richmond-Norfolk route options as background for scoping the proposed environmental study.

2.4.2 Potential Route Options from Newport News to Richmond

The initial Phase 2(B) assessment assumed only Amtrak service with one added daily round trip to Newport News. But it soon became apparent that development of the Richmond Direct option could offer a synergistic opportunity to add a Peninsula connection, so diesel trains from the Peninsula and electric trains from the Southside could share a common entryway into downtown Richmond[15]. This was originally explored only as a sensitivity analysis, Option 4 – Richmond Direct Improved. See Exhibit 2-9.

Exhibit 2-9: Option 4 - Richmond Direct Improved



[15] The potential for track sharing depends on which Norfolk option is selected during the environmental process. If the Richmond Direct Option 3 were selected then there is significant sharing potential. If the Northern Greenfield Option 2 via Hopewell were selected, then the final approach inside the I-295 beltway could be shared. However, selecting the Southern Greenfield Option 1 via Petersburg would practically eliminate the potential for Peninsula track sharing, since this alternative enters Richmond from the south rather than from the east. However, all of these options could still share the line from Richmond to Washington, D.C.

This resulted in development of a new concept for linking the Richmond Direct corridor using a new greenfield connection across open countryside to Toano.[16] However, the original 2(B) report was not specific about how a greenfield connection could be made because the option was assessed only as a sensitivity, so the Capital cost was assessed based only on benchmarking.

This report has looked at the development of rail service for the Peninsula, including greenfield alignment issues in more detail. A preliminary environmental scan has been performed and feasibility-level engineering costs have been developed for one representative route from Roxbury to Toano. Specific assumptions for this route will be detailed in Chapter 3. This section provides a high level overview of possible options for developing rail service on the Peninsula. This could be useful in helping define a possible scope for a Tier I EIS that includes greenfield options as well as existing rail alignments.

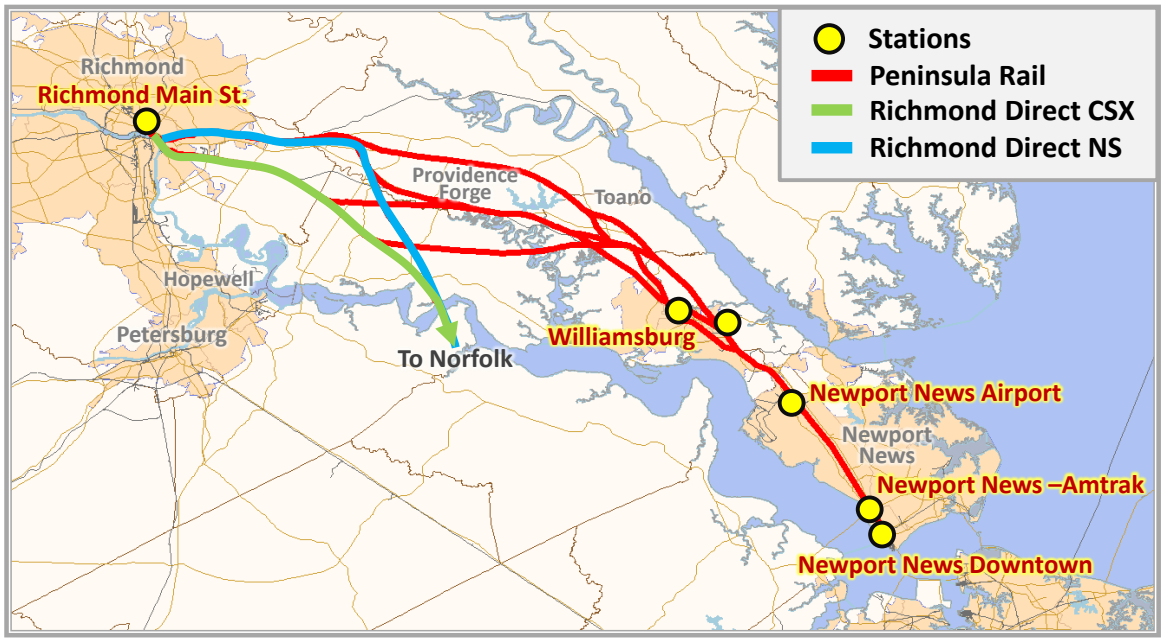
Exhibit 2-10 presents a concept for developing the Newport News to Richmond corridor in conjunction with Richmond Direct High Speed service to Norfolk:

- The Green line on Exhibit 2-10 corresponds to the Richmond Direct alignment that was proposed as part of the original Phase 2(B) work. This alignment crosses the James River on a high-level bridge just south of Charles City, then arcs northwesterly to line up with the CSX tracks entering Richmond south of the airport. Although it would parallel the CSX corridor from the vicinity of I-295, this Richmond Direct option would not share the existing CSX tracks, rather a new double-tracked electrified greenfield would be built on the north side of the existing rail alignment.
- As a new alternative, the Blue line on Exhibit 2-10 corresponds to a "shifted" Richmond Direct alignment, farther east than was envisioned by the original Phase 2(B) study, which would line up with the NS tracks entering Richmond north of the airport. Since the NS entrance into Richmond is only a lightly used branch line, this option assumes that the rail line and right-of-way would be purchased from Norfolk Southern so improved tracks could be constructed on the existing track bed.[17] This is likely to be less costly than greenfield construction and results in an effective Acca Yard bypass. However, it increases the length of the alignment to Norfolk by 5 miles.
- The Red lines in Exhibit 2-10 all correspond to various Peninsula alternatives that might be considered by a future environmental study. These alignments all connect to either the Green or Blue Richmond Direct options for sharing access into downtown Richmond with the Norfolk High Speed trains.

[16] A connector could be developed as an adjunct to the proposed Richmond Direct alignment, since the countryside between Richmond and Toano is still relatively open. From Williamsburg to Newport News, development density is much higher. This limits available options east of Toano to existing corridors: CSX, I-64, or utility rights of way.

[17] Freight service could still run in the mid-afternoon, evening and night hours since passenger train speeds over this portion of the alignment will be restricted due to geometric concerns. Strict temporal separation would not be necessary because the passenger trains will be able to share tracks with freight trains at under 125-mph, under the proposed FRA Alternative Tier I equipment regulations.

Exhibit 2-10: Potential Rail Routes* in the Newport News to Richmond Corridor



**Alignments will not be determined until the Tier II Environmental Process is complete.*

For understanding the characteristics of these possible alignments, Exhibit 2-11 shows the Peninsula route options by Right-of-Way type. The selected representative route via Roxbury and Toano is highlighted in Exhibit 2-12.

Exhibit 2-11: Potential Peninsula Route Alignments by Right-of-Way Type

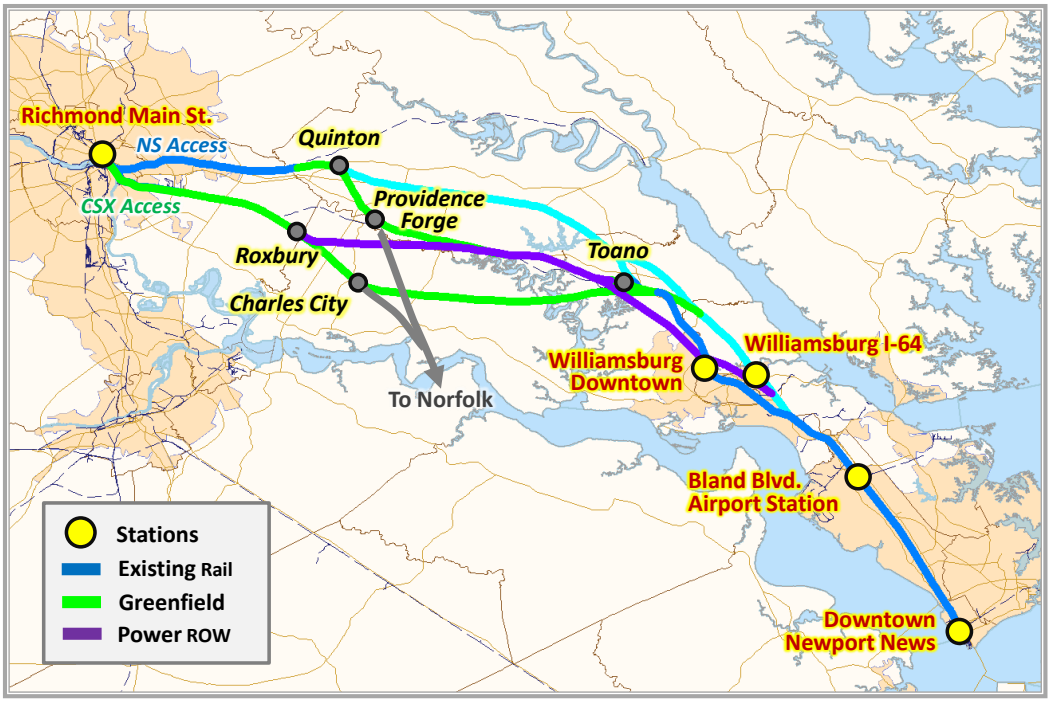
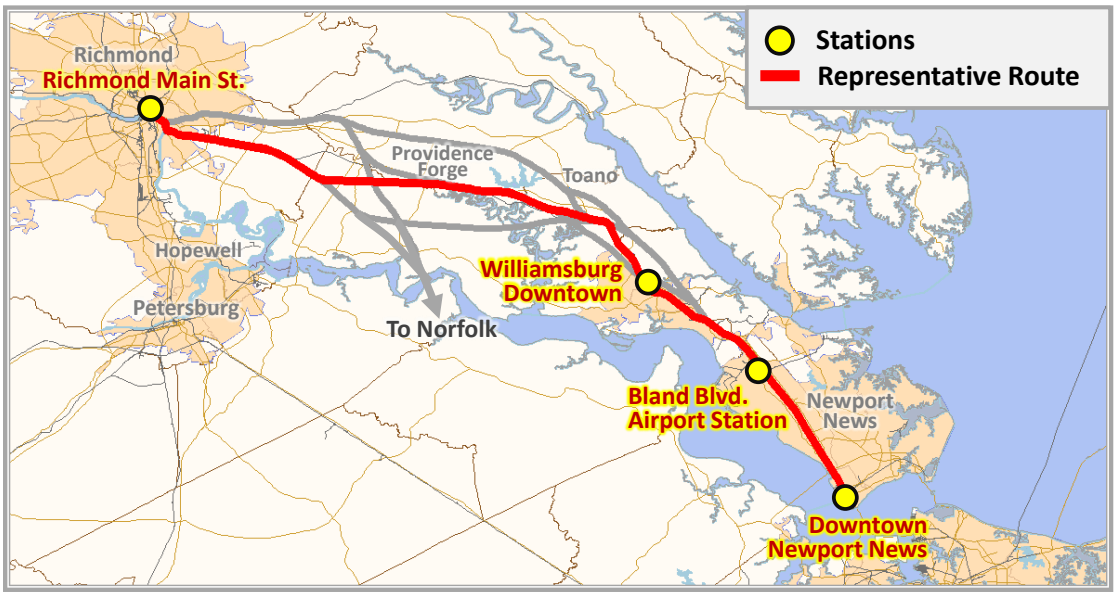


Exhibit 2-12: Peninsula Representative Route via Toano and Roxbury



First, the representative route will be described: Starting in downtown Newport News[18], the existing CSX rail alignment would be used past the stations at Bland Boulevard and Williamsburg, to Toano. Top speed would be limited to 90-mph in this stretch. From Toano a dedicated alignment would follow a power line right-of-way to Roxbury. Diesel trains could achieve 130-mph on this section, which would be fully grade-separated. From Roxbury the route would join the Richmond Direct 220-mph line shared with Norfolk service, entering Richmond on a new greenfield alignment paralleling CSX past the airport.

It was noted that an existing utility corridor extends all the way from Roxbury through downtown Williamsburg to Busch Gardens (see Exhibit 2-11.) For development of the representative route it was decided to utilize this existing utility corridor[19] from Roxbury to Toano, because it is very straight and minimizes the need for property takes (other than some utility pole relocations, as needed.)

For development of alternatives for the environmental study, it should be noted that just east of Busch Gardens, the CSX alignment comes very close to the I-64 highway allowing a transition to the highway alignment if desired. This was originally proposed by Dodson[20] in his 1993 study of Peninsula rail options. Dodson proposed only to use I-64 to bypass the curvy stretch of track through downtown Williamsburg, from Busch Gardens to Toano. At Toano, Dodson's 1993 alignment returned to the CSX rail alignment, rather than continuing on I-64 all the way to Richmond.

However, VDOT plans to add lanes to I-64[21] which may conflict with potential rail use of the corridor. Initial plans are only to add lanes from Jefferson Avenue (exit 255) to Lee Hall (exit 247), but these may eventually extend as far as Lightfoot, west of Williamsburg.

[18] For the purpose of this study, it is assumed that Peninsula rail service will start at a new downtown Newport News station, stop at Bland Boulevard and continue on to Williamsburg. This is consistent with current official HRTPO planning documents, see: http://www.hrtpotip.org/PDFs/T9097.pdf as well as previous DRPT plans for development of Peninsula rail service. The FRA Record of Decision http://www.fra.dot.gov/Elib/Document/2710 for the current DRPT Tier I FEIS is based on current Amtrak stations on the Peninsula, but leaves final station selection up to the municipalities, saying that: *Specific station sites will be determined in the future by the municipalities, and appropriate levels of environmental documentation will be undertaken at that time.*

[19] An alternative greenfield from Toano to Charles City crosses the Chickahominy River farther south where the river is still navigable, and would likely need a high level bridge crossing. Property takes are also a concern for the Charles City alignment. Farther north along the utility corridor to Roxbury, there is a need to span wetlands but not navigable river.

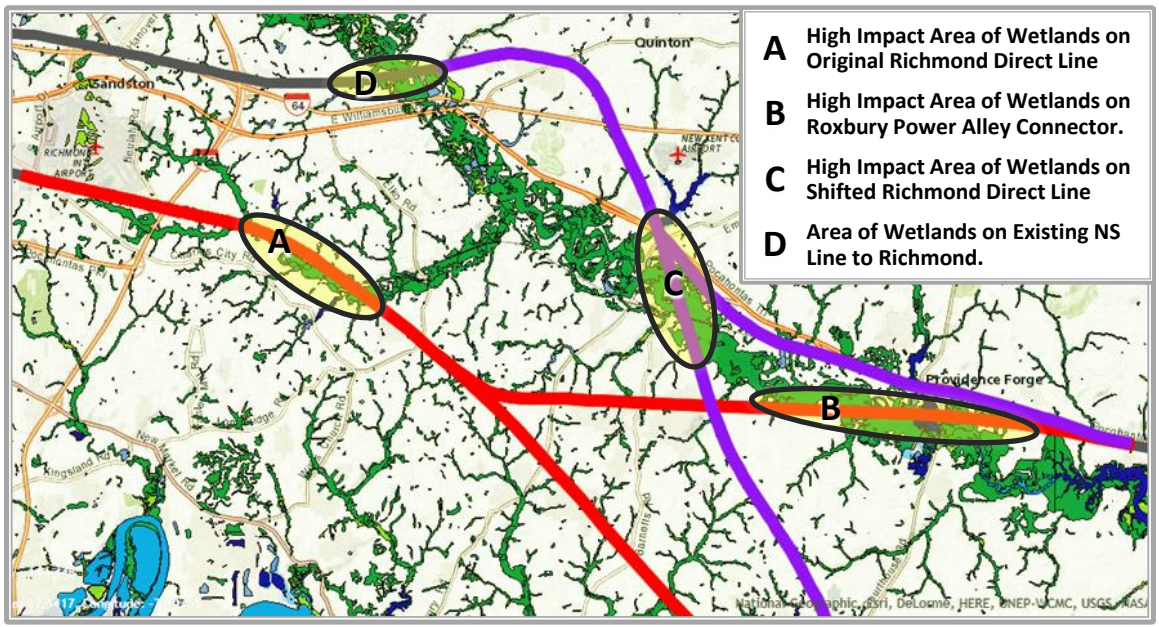
[20] *Richmond - Hampton Roads Passenger Rail Project Tier 1 Final Environmental Impact Statement (EIS)*, DRPT, August 2012, see http://www.fra.dot.gov/eLib/Details/L03722 and *Preliminary Engineering Feasibility Study*, D. W. Dodson, August 1993, see Appendix G.

[21] See: http://wydaily.com/2014/05/01/vdot-hosts-public-hearing-on-i-64-widening/

- From Busch Gardens to Toano, the I-64 median is approximately 85' wide, which if highway lanes were added may not leave enough room to also fit rail tracks into this segment of the corridor.
- Further west from Toano to the I-295 Junction at Quinton, the I-64 median widens to 250-300' most of the way, although it narrows to 125' as I-64 approaches I-295. Because of this wide median, rail development may be easier along west end of I-64 between Toano and the I-295 Junction, than it will be along the central portion from Busch Gardens to Toano.[22]
- For connecting an I-64 option to downtown Richmond, it should be noted that I-64 joins the Norfolk Southern (NS) alignment east of Richmond. As a result it makes more sense to use the NS entry into Richmond rather than CSX in conjunction with an I-64 option.

So as not to preclude future consideration of an I-64 option, the possibility for shifting the Richmond Direct alignment eastward and northward to enter Richmond via NS rather than CSX has also been considered. This has both advantages as well as disadvantages; a full environmental analysis will likely be needed to discriminate the differences.

Exhibit 2-13: Wetland Crossings associated with Peninsula Alternatives


A High Impact Area of Wetlands on Original Richmond Direct Line
B High Impact Area of Wetlands on Roxbury Power Alley Connector.
C High Impact Area of Wetlands on Shifted Richmond Direct Line
D Area of Wetlands on Existing NS Line to Richmond.
A
B
C
D
Quinton
Providence Forge

As shown in Exhibit 2-13:

- The original Richmond Direct alignment parallel to CSX (red line in Exhibit 2-13) crosses an area of wetlands in area A. This will need to be mitigated by bridging the wetlands and by using environmentally sensitive construction[23]. Adding a Peninsula connection from Toano to Roxbury introduces a second area of wetlands, area B, which will also need to be mitigated by bridging.

[22] Detailed discussion with VDOT is needed to find out whether any portion of I-64 may have room to accommodate a rail alignment. This should be done as part of the environmental process. To stand any chance of preserving a possible I-64 footprint for a rail alignment between Busch Gardens and Toano, early consultation with VDOT is needed. Unless a right-of-way reservation is preserved, highway development will likely consume the needed right-of-way between these points.

[23] See *Low Impact Development* at http://water.epa.gov/polwaste/green/

- The shifted Richmond Direct alignment utilizing NS (purple line in Exhibit 2-13) crosses an area of wetlands in area C. This will need to be mitigated by bridging the wetlands. By linking from Toano to Providence Forge or using I-64 median, the Peninsula connection remains north of the wetlands.[24] The shifted Richmond Direct alignment also has a second wetland crossing at area D. However, this second crossing has already been compromised by the existing railroad fill so it likely would require at the most, retaining walls to widen the footprint with minimal wetland impact.[25]

In summary, it is recommended to maintain flexibility at the current time since the optimal location for the Richmond Direct alignment may also be dependent on the environmental issues associated with developing a Peninsula greenfield connection. The two should be jointly optimized. While shifting the Richmond Direct alignment east and north may reduce wetland impacts, it may also increase the need for direct property takes. In addition, shifting the alignment north and east would add five miles to its length, which will cause an undesirable perpetual increase in operating cost and transit time. The ability to use any part of the I-64 highway or Norfolk Southern rail alignment is not known at this time. These issues are too complex to be resolved at the current level of study and so will need a full environmental analysis to be sure of locating the optimal alignment.

2.4.3 Hypothetical Route Options from Richmond to Washington D.C.

For updating the capital costs, it has been necessary to estimate costs for one representative route from Richmond to Washington D.C., since a greenfield alignment north of Richmond forms an essential component of the Hampton Roads corridor. A high quality alignment north of Richmond is needed to support High Speed rail service to the Southside and Enhanced Passenger Rail on the Peninsula, as called for by HRTPO Board Resolution #2009-05. The current study scope did not enable the development or environmental review of any actual alignments north of Richmond. However, a very preliminary mapping analysis had already been conducted for establishing costs for the 2010 study along with a review of published reports. For satisfying our due diligence obligation is regard to representation of financial and economic results for the overall corridor, this earlier analysis was brought up to date.

A preliminary assessment suggests that a broad range of options may exist for linking Richmond north to Fredericksburg, through mostly rural lands. North of Fredericksburg the options are much more limited. In concept, many different combinations of greenfield, electric utility right-of-ways, highway and existing rail alignments, may be assembled for developing route alternatives between Richmond and Washington D.C. A comprehensive assessment will require a full environmental study. However, to preserve the potential for developing greenfields, such a study should be undertaken with some urgency. Even if actual construction may be some years away, it is important to establish the needed right-of-way reservations by including them in local master plans *before* development further encroaches open land areas. Moving expeditiously to preserve rights of way will minimize the cost escalation that California's rail system reported.[26]

[24] This link to Providence Forge will likely have more property taking impacts than the representative alignment that follows power line right-of-way to Roxbury, but less wetlands impacts.

[25] However, we cannot be sure of this without a detailed engineering analysis. If it is not possible to share the existing NS right-of-way but rather need to develop a new dedicated alignment parallel to the existing rail line, the added width of the right-of-way on this wetland crossing will likely undermine much of the environmental benefit. This will have to be assessed by a future study.

[26] See: http://www.hsr.ca.gov/docs/about/business_plans/BPlan_2012Ch3_Cap_Cost.pdf *"The initial program planning predated much of California's real estate boom in the mid-2000s. Large expanses of vacant or under-utilized property, over which the system would have operated at-grade, have since become bustling communities, suburbs, and roadways. California added nearly 5 million people between 2000 and 2010, with much of this growth along the project route. In many areas, the alignment has had to be relocated, elevated on bridges, or placed in tunnels to avoid severe community impacts and to navigate through densely populated urban areas. In addition, more detailed investigations during Preliminary Engineering have identified challenging geologic and geotechnical conditions, floodplains, and differences in terrain that required realignment of the route or more expensive design approaches."*

2.5 TRAIN TECHNOLOGY OPTIONS

The key element for developing an operating plan is the technology selection from a range of alternative technologies available. In the case of the slower speed alternatives (79-110 mph), the most effective option is using existing railroad rights-of-way and where the volume of freight rail traffic is limited, to share tracks with freight traffic. As speeds and frequency of passenger rail service increase, the ability to share tracks with freight becomes more limited, although if wide enough the right-of-way may still be shared. For very high speeds the ability to even use existing railroad rights-of-way is typically lost. Of course, sharing track or using freight rail right-of-way may still occur (at lower speeds) in urban areas to gain access to downtown stations, but away from the urban area true high speed service is likely to require a greenfield route – since high speed rail operations need long stretches of straight track and very gentle curves to achieve high speed. Even sharing Interstate highway right-of-way may not be possible since they frequently have curves that are too tight for the faster trains. In general, faster systems have fewer stops. A compromise may be needed to ensure all key communities are served, but this results in a trade-off between end-to-end speed and connecting communities. Each station stop takes three to seven minutes (including deceleration, stop time and acceleration back to speed) so multiple stops soon dramatically increase end-to-end running times.

A key study assumption that determines transit time is a passenger car's "tilt" or "non-tilt" design. The track in curves is typically banked (super-elevated) up to six degrees (6° or 6"), which results in designation of a balance speed for each curve (at which speed a vehicle occupant would feel no sideways force in the curve). However, up to four degrees (4° or 4") of imbalance (cant deficiency) is acceptable for passenger comfort. Beyond this, onboard hydraulic systems (active tilt) or car suspension designs (passive tilt) can permit even higher speeds, by lowering the centrifugal forces felt inside cars.

True high speed trains typically do not include tilting mechanisms, because the allowable cant deficiency reduces to only 2.5 degrees (2.5° or 2.5") at 220 mph[27]. This limitation on cant deficiency at the wheel-rail interface eliminates the benefit of tilt for true high speed rail. It should be noted that the geometric standards for interstate highway alignments generally allow speeds of 125-150 mph, which are in the effective range for tilting trains, but the curves are usually too sharp to support true high speed trains (186 mph+). As a result, high speed trains need very gentle curves, which are typically only obtained through development of new "greenfield" alignments. Tilting capability may still be beneficial to high-speed trains however, on shared segments of existing line on urban approaches, or for extended operations beyond the limits of the high speed territory.

Another key issue for determining the suitability of train technology is compliance with FRA safety requirements. The FRA Tier I safety requirements allow speeds up to 125 mph. More stringent Tier II requirements are applied to passenger trains operating with speeds 125-150 mph. The FRA Railroad Safety Advisory Committee (RSAC) recently announced "Alternative Tier I" compliance standards[28] that could make it easier to adapt European train designs to meet United States requirements.

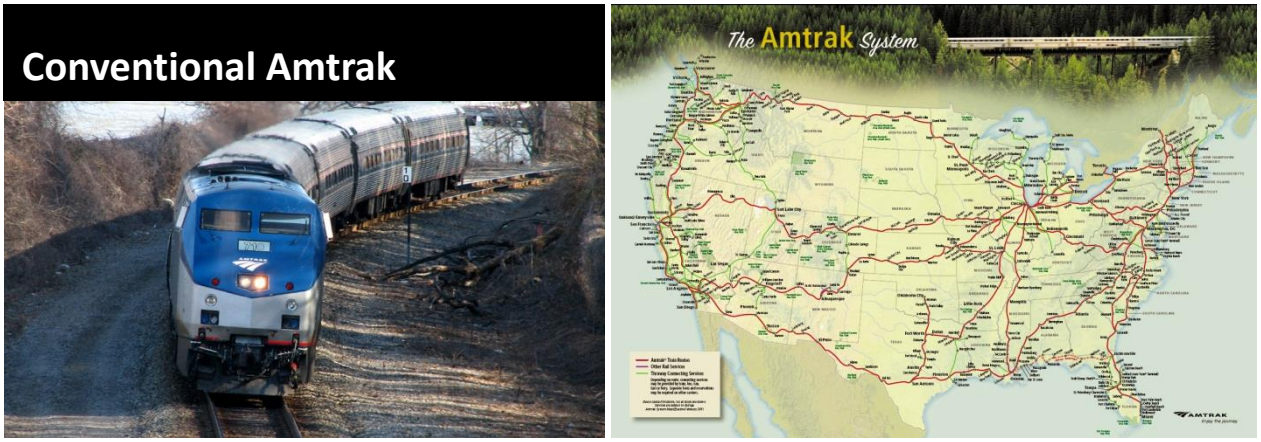
Conventional Rail – 79 mph or less: Conventional trains, as shown in Exhibit 2-16, typically operate at up to 79 mph on existing freight tracks. 79 mph represents the highest speed at which trains can legally operate in the United States without having a supplementary cab signaling system on board the locomotive. The key characteristics of these trains are that they:

[27] *See: http://www.scribd.com/doc/24548877/High-Speed-Railway-Lines-en*
[28] Railway Track and Structures, http://www.rtands.com/index.php/track-maintenance/off-track-maintenance/rsac-recommends-passenger-rail-crashworthiness-standards-to-accommodate-hsr.html

- Are designed for economical operation at conventional speeds
- Can be diesel or electric powered
- Are non-tilting for simplified maintenance

Conventional rail is used for example by Amtrak in corridors across the country outside the Northeast corridor. Such trains do operate at up to 110 mph in developing corridors in Illinois and Michigan, but they need an extra locomotive in order to attain satisfactory acceleration or braking performance. The high center of gravity of the P-42 locomotive limits its safe speed around curves, as compared to higher speed trainsets, which are designed to have a lower center of gravity.

Exhibit 2-16: Conventional Rail – Representative Trains and Corridor Service



Higher Speed Rail - 110-130 mph: A 110 to 130-mph service can often be incrementally developed from an existing conventional rail system by improving track conditions, adding a supplementary Positive Train Control safety system, and improving grade crossing protection. Tilt capability, built into the equipment can be used to allow trains to go around curves faster, and has proven to be very effective for improving service on existing track, often enabling a 20-30 percent reduction in running times. Trains operating at 110 mph, such as those proposed for the Midwest, Ohio Hub and New York State systems (See Exhibit 2-17), have generally been found to be affordable, produce auto-competitive travel times, and are able to generate sufficient revenues to cover their operating costs.

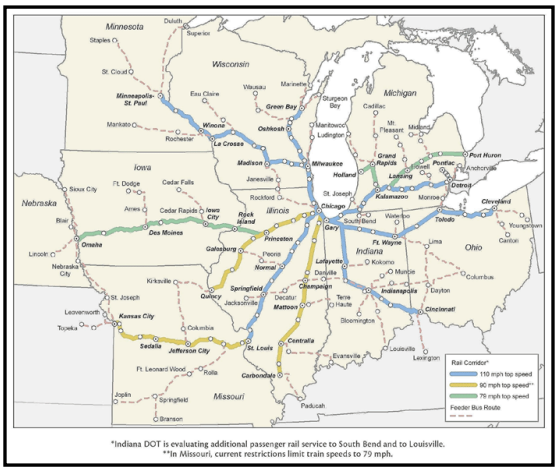
Higher speed trains:

- Are designed for operation above 110 mph on existing rail lines and diesel trains can attain sustained speed of 130 mph on dedicated grade separated rights of way.
- Can be diesel or electric powered.
- Are usually tilting unless the track is very straight.

In the United States, 110-mph service has been seen to provide a low cost infrastructure option by using existing railroad rights-of-way, and quad-gating crossings, which are relatively low cost options. However, it may contradict some existing freight railroad passenger principles unless additional improvements are made. For example, while Norfolk Southern's passenger principles do not prohibit the operation of higher speed tilting trains, they do prohibit speeds above 79 mph on Norfolk Southern-owned rights of way. CSX policies have generally prohibited operations above 90 mph. To reach 110-mph speeds or higher an alternative arrangement, such as the purchasing of a parallel strip of right way, or

right-of-way easement and separate ownership of the track may be needed to comply with the requirements of the freight railroads.

Exhibit 2-17: High Speed Rail Shared Use (Diesel) – Representative Trains and Corridor Service



High Speed Rail - 130-220 mph: The costs of grade separation for 125 mph can easily double the capital cost of a project, as the number of public and private crossings can be as many as two per mile. This is why true high speed rail is typically twice the cost per mile of higher speed rail. Once full grade separation has been accomplished however, speeds can be pushed up to 220 mph by electrification and the use of Electric train systems. This will tend to improve further the economic return on capital investment.

Representative trains include the Amtrak Acela Electric locomotive hauled train as well as the proposed California trainset shown in Exhibit 2-18. While initially the Acela speed was limited to 150 mph, it is now being tested at speeds of 160 mph. However, this concept has been superseded by the joint equipment procurement by Amtrak and the California High-Speed Rail Authority, as well as Amtrak's cancellation of its own intended Acela fleet expansion for the Northeast Corridor. Instead, California and Amtrak intend to collaborate on the purchase of a common fleet of high speed electric trains[29]. It should be noted that in the last twenty years electric high speed train technology has evolved rapidly from 150 mph maximum speed to 220 mph maximum speed. This revolution in train capabilities has been due to rapid advances in the design of the propulsion system of modern electric trains. It is assumed that new electric trains based on the new standards will be able to operate up to 220 mph on dedicated alignment and still be able to comingle with freight trains on the same tracks as needed, at speeds under 125 mph. Both Amtrak and California have produced feasibility and business plans showing the advantage of moving to 220-mph technology.

[29] See: http://www.amtrak.com/ccurl/620/710/Amtrak-CHSRA-Joint-RFI-HSR-Train-Sets-ATK-13-012.pdf

Exhibit 2-18: High Speed Rail Shared Use (Electric) – Representative Trains and Corridor Service

2.5.1 OTHER ROLLING STOCK AND OPERATIONAL ASSUMPTIONS

Consistent with the assumptions customarily made in feasibility-level planning and Tier I EIS studies, the following general assumptions are proposed regarding operating requirements for the rolling stock:

- Trains will be reversible for easy push-pull operations (able to operate in either direction without turning the equipment at the terminal stations);
- Trains will be accessible from low-level station platforms for passenger access and egress, which is required to ensure compatibility with freight operations;
- Trains will have expandable capacity for seasonal fluctuations and will allow for coupling two or more trains together to double or triple capacity as required;

- Train configuration will include galley space, accommodating roll-on/roll-off cart service for on-board food service. Optionally, the trains may include a bistro area where food service can be provided during the entire trip;
- On-board space is required for stowage of small, but significant, quantities of mail and express packages, and also to provide for an optional checked baggage service for pre-arranged tour groups;
- Each end of the train will be equipped with a standard North American coupler that will allow for easy recovery of a disabled train by conventional locomotives;
- Trains will not require mid-route servicing, with the exception of food top-off. Refueling, potable water top-off, interior cleaning, required train inspections and other requirements will be conducted at night, at the layover facilities located at or near the terminal stations. Trains would be stored overnight on the station tracks, or they would be moved to a separate train layover facility. Ideally, overnight layover facilities should be located close to the passenger stations and in the outbound direction so a train can continue, without reversing direction, after its final station stop; and
- Trains must meet all applicable regulatory requirements including:
    - FRA safety requirements for crash-worthiness,
    - Requirements for accessibility for disabled persons,
    - Material standards for rail components for high speed operations, and
    - Environmental regulations for waste disposal and power unit emissions.

2.5.2 SOUTHSIDE ROUTE AND TECHNOLOGY OPTIONS

The three main route options described above (including the two variant options that utilize the Norfolk Southern alignment), have been assessed at two maximum train speeds: 130 mph and 220 mph, consistent with the capabilities of modern diesel and electric train technologies. As a result, the following Exhibit (2-19) shows the five routes and two technology/speed combinations have been assessed for the Norfolk-Richmond segment in this study, leading to a total of ten options:

Exhibit 2-19: Study Options Assessed for the Southside

OPTION	VARIANT	SPEED
Southern Option 1 – via Petersburg	Southern Option 1A - Greenfield	130 / 220 mph
	Southern Option 1B - Norfolk Southern	130 / 220 mph
Northern Option 2 – via Hopewell	Northern Option 2A - Greenfield	130 / 220 mph
	Northern Option 2B - Norfolk Southern	130 / 220 mph
Option 3 – Richmond Direct	----	130 / 220 mph

To avoid biasing the analysis, the same capabilities have been assumed for all segments of alignment, so train speeds are limited by only equipment capabilities and track geometric restrictions. For comparative purposes, all alignments are assumed to be double tracked and fully grade separated. As a result, a top speed of 130 mph was assumed for diesel trains in all options, and 220 mph for electric trains.

In terms of the "B" options that involve segments of Norfolk Southern right-of-way between Suffolk and Petersburg, these have been assessed on an equitable basis based on geometry, since the existing rail alignment is arrow-straight between Suffolk and Poe, on the outskirts of Petersburg.

In the short term these Norfolk Southern options may be easier to develop on an incremental or phased basis, assuming that the agreement of the freight railroad can be gained to install the incremental improvements. However, care must be taken in pursing incremental development of the existing rail corridor west of Suffolk to ensure that the speed capability is in fact, ultimately extendable to support the ultimate 220 mph build-out of the system, if it were decided to pursue such incremental options.

2.5.3 PENINSULA TECHNOLOGY OPTION

Due to the lack of electrification east of Toano, only one train technology type has been considered for the Peninsula: the modern 130-mph tilting diesel train. While this train can reach up to 130-mph on dedicated High Speed tracks, it would be limited to 90-mph on CSX east of Toano as well as north of Aquia Creek on the shared right-of-way to Washington D.C.

In a future study the option of a dual mode train may also be considered. A dual mode diesel/electric train may save 15 minutes on the timetable between Newport News and Washington D.C. by being able to run 220-mph west of Toano[30], and an additional 20-30 minutes saved by not needing to change the locomotive in Washington D.C. Currently a Newport News diesel train could run as far north as Philadelphia, PA under diesel power but it could not continue into New York City without either changing to an electric locomotive or having dual-mode capability. It should be noted that not needing to change locomotives in Washington D.C. will also significantly enhance the capacity of the lower level Union Station platform tracks. As an enhancement to the current Peninsula option, this should be considered in the next phase of study.

2.5.4 TECHNOLOGY OPTIONS SUMMARY

In terms of development of the passenger rail service to Hampton Roads, as described in Chapter 1, the original Phase 2(B) report developed a series of "steps" describing a phased build out option for the system. As described in Chapter 1, Exhibit 1-2, the first two "steps" represented short term actions based on conventional Amtrak train technology. Step 3 was based on High Speed Diesel, and Step 4 on High Speed Electric train technology. So as not to duplicate the work that DRPT was doing, the original Phase 2(B) study focused only on Steps 3 and 4, the High Speed rail options.

As a result of this earlier work it became clear that given the high cost associated with developing greenfield routes from Norfolk to Richmond to Washington D.C, electrification to run at 220-mph (instead of just 130-mph) was a good choice. For the southside, a 220-mph electric service produced better Cost Benefit results than did the 130-mph diesel options. The southside option producing the best financial and economic results was Option 3 – Richmond Direct, electrified at 220-mph which formed the starting point for the Peninsula supplemental analysis.

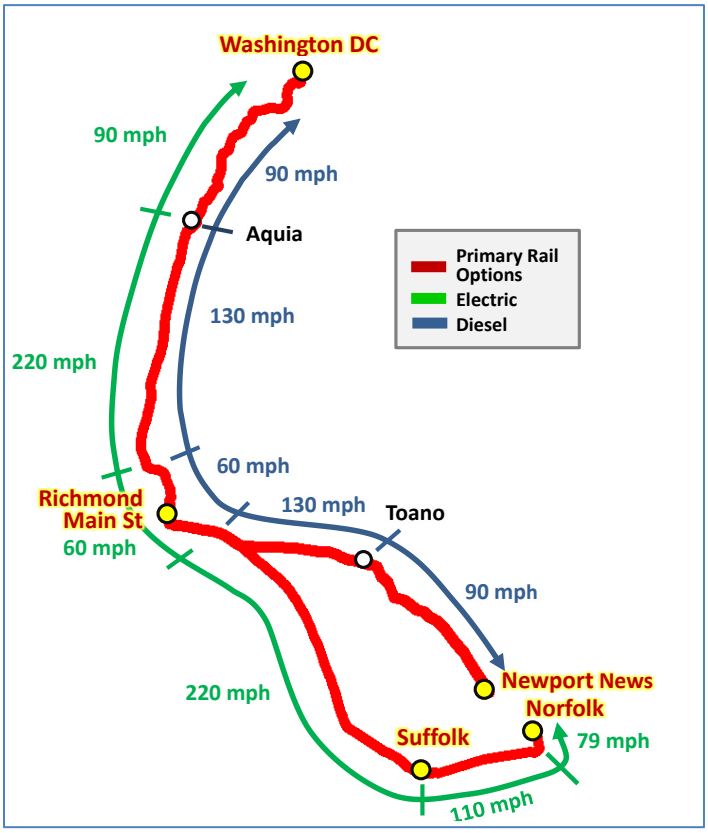
[30] Or Roxbury, if electrification is not extended onto the Roxbury-Toano greenfield segment.

As a result, the current preferred Option 4 – Richmond Direct Improved is comprised of two distinct components, as shown in Exhibit 2-20:

- **A 220-mph High Speed electric train for the Southside, assuming electrification extends all the way to Harbor Park in downtown Norfolk:** However, speeds on the shared CSX alignment north of Aquia would be limited to 90-mph. On a short stretch through downtown Richmond, speeds would be limited to 60-mph or less. It is assumed that the "V-Line" right-of-way would be purchased from Norfolk Southern* so it can be upgraded to 110-mph, the highest speed allowed by FRA without grade separation of all highway crossings. From South Norfolk to Norfolk Harbor Park, speeds would limited to 79-mph on shared right-of-way, consistent with Norfolk Southern's policy.

- **A 130-mph High Speed diesel train for the Peninsula, assuming diesels can run "under the wire" at 130-mph:** However, speeds on the shared CSX alignment north of Aquia would be limited to 90-mph. On a short stretch through downtown Richmond, speeds would be limited to 60-mph or less. Beyond Toano on shared CSX track to Newport News, diesel trains would share the existing rail corridor at 90-mph, consistent with CSX policy.

Exhibit 2-20: Southside Electric and Peninsula Diesel Components of Hypothetical Combined System



*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

3. ROUTE ANALYSIS

Route options have been developed at a conceptual level based on a mapping analysis of the routes. Particularly for new greenfield alignments, environmental considerations not only determine where an alignment might go, but also directly drive the capital costs in terms of unavoidable consequences and mitigation costs. Particular attention has been paid to crossings of highways and other rail lines, required property takings, river bridges and wetland crossings since these are key capital cost drivers. This route analysis focuses primarily on the factors that directly impact capital cost and develop the key environmental and engineering findings, upon which the preliminary capital cost development for each option will be based.

3.1 DEVELOPMENT OF ROUTE OPTIONS

The focus of this study is on further developing the two Hampton Roads to Richmond segments of the Hampton Roads High Speed rail corridor, both from Richmond to Norfolk as well as to Newport News. Chapter 2 first proposed three conceptual Options 1-3 for linking Norfolk to Richmond on a new high speed alignment. These options were fully developed at the Feasibility Level by the original Phase 2(B) study.[1] Subsequently the scope of the study was supplemented to allow development of one option for Peninsula rail service (Option 4, as an add-on to the Richmond Direct high speed alignment.) For completing the capital cost estimate to include the critical Richmond to Washington D.C. link, the assumptions of the original 2010 feasibility study were carried forward. This allows the financial and economic analysis to reflect the full utility of connecting NEC traffic, since even today, ridership to Washington D.C. and points north is a critical component of Amtrak ridership, and even the existing passenger rail service could not be sustained without it. With High Speed rail in the future, improving the link north to Washington D.C. will become an even more critical component of the overall plan for implementing High Speed rail service to Hampton Roads.

3.1.1 NORFOLK TO RICHMOND ROUTE OPTIONS

Chapter 2 of the original Phase 2(B) study proposed three conceptual options for linking Norfolk to Richmond on a new high speed alignment. These are routes via: Petersburg, Hopewell, or Richmond Direct. The Petersburg and Hopewell options have two variants: where the "A" variant is a new greenfield alignment, and the "B" variant would utilize the existing Norfolk Southern rail corridor from Suffolk to Petersburg.

This makes five route options in total (see Exhibit 3-1), which are called 1A, 1B, 2A, 2B and 3, respectively. However, the 1B and 2B options share the Norfolk Southern segment from Suffolk to Petersburg. This option for developing a dedicated track along the Norfolk Southern Suffolk to Petersburg line will be developed only once, for both options. Because of this overlap, *four* route segments will be developed in this chapter:

> **1A– Southern Greenfield via Petersburg** would link Kilby to Burgess, south of CSX's Collier Yard in Petersburg. From Burgess the alignment would follow the SEHSR through Petersburg to Woods Edge Road. There, the alignment would leave the CSX rail corridor, parallel I-95 for a short distance, cross the James River and enter a possible "East Shore Greenfield" through open land to Richmond.

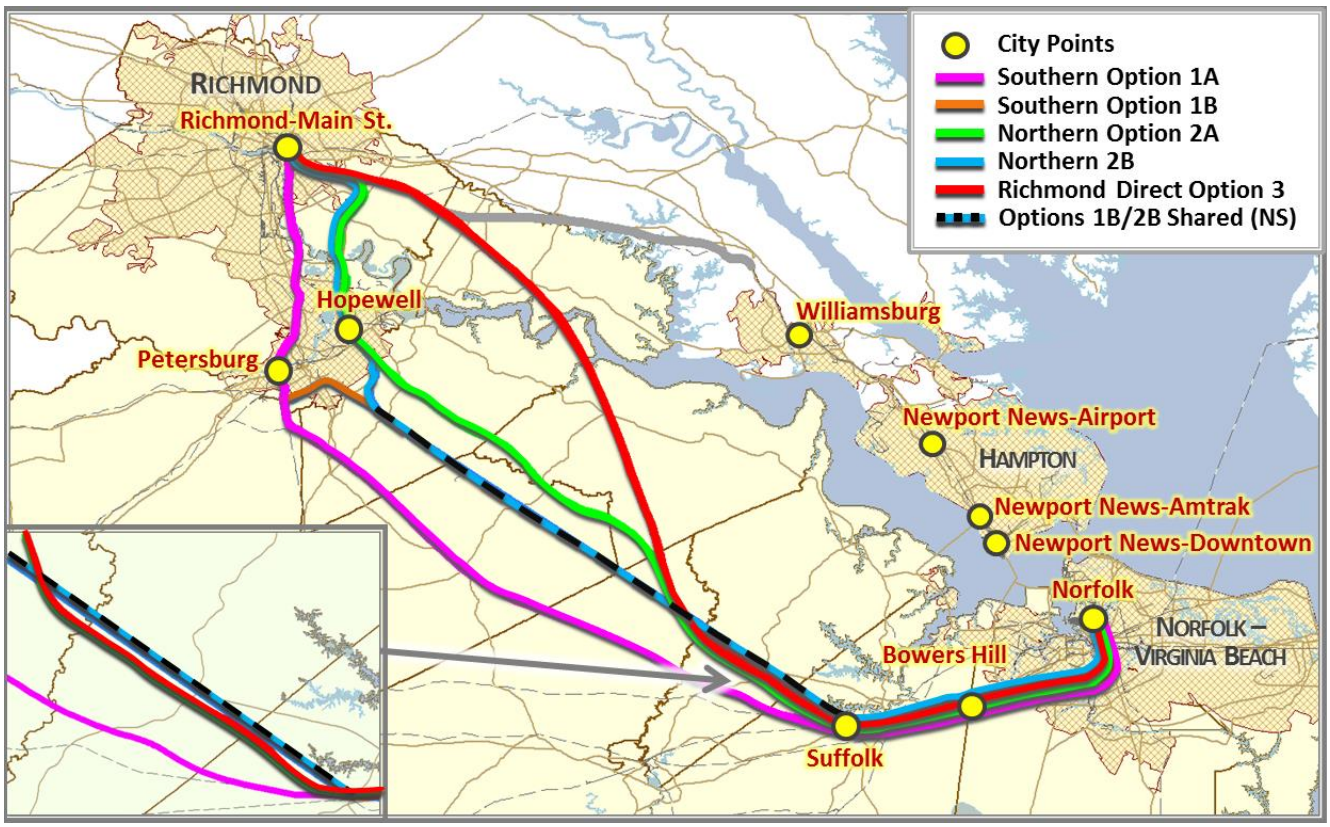
[1] However, it should also be noted as a result of CSX discussions that occurred during the course of the Phase 2(B) supplement, a small adjustment to the original plan for developing a High Speed rail alignment through Suffolk has been made. As a result of this refinement, passenger trains can now be fully separated from freight trains through Suffolk. However, the plan will be subject to re-review and possible revision during the course of the environmental studies that are needed to further progress the system towards implementation.

2A – Northern Greenfield via Hopewell would link Kilby to Hopewell, then follow I-295 north to Richmond. The alignment would leave I-295 where it crosses the CSX Peninsula Subdivision, and parallel the CSX rail line into Richmond Main Street Station

3–Richmond Direct Greenfield would head directly to Richmond on the shortest practicable routing through open land. It would cross the James River near Charles City and line up with the CSX Peninsula Subdivision just east of the I-295 crossing. From here it would parallel the CSX rail line into Richmond.

1B and 2B *(Common Segment from Suffolk to Petersburg)* – Dedicated Tracks Along the Existing Rail Corridor would develop dedicated infrastructure closely following the Norfolk Southern mainline to Poe, on the eastern outskirts of Petersburg. From Poe, the corridor would either follow the Belt Line to Collier and connect to the planned Southeast High-Speed Rail (SEHSR) through Petersburg; or else it would follow the I-295 highway median north via Hopewell to Richmond.

Exhibit 3-1: Norfolk-Richmond Route Options Assessed for the Engineering Analysis



All options share a common segment using the existing "V-Line" rail alignment from Norfolk Harbor Park to a rail junction called "Kilby" on the west end of the City of Suffolk. Beyond Kilby, the new Greenfield options 1A, 2A and 3 have been developed, to offer an alternative to options 1B and 2B that would develop a dedicated track paralleling the Norfolk Southern rail right-of-way, and also to address the issue of how to connect the high speed alignment north to Richmond.

*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

These high speed rail options include two segments in urban areas, where the tracks would be shared with freight trains at reduced speeds. These are:

- Norfolk Harbor Park to Kilby on NS and CSX
- Collier to Dunlop (Woods Edge Road) on CSX (enhanced SEHSR plan)

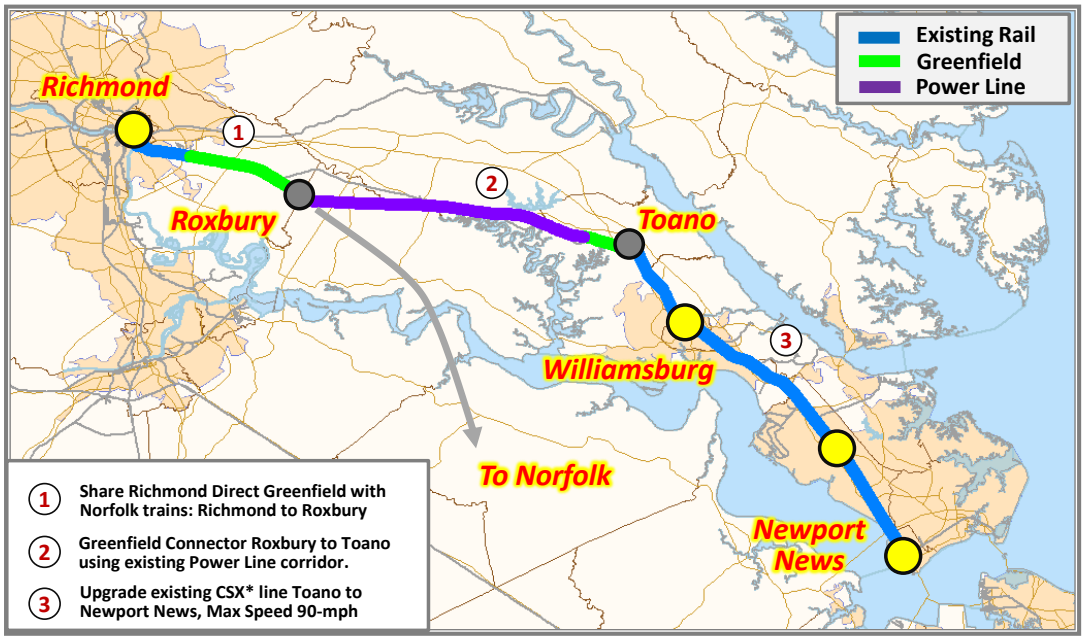
These two segments are based on existing rail alignments and have been subject to previous Environmental studies, so the assumptions for these segments can be spelled out in some detail. However, some of the earlier engineering assumptions may need to be adjusted for supporting the higher service intensities that are associated with high speed rail operation, particularly the need for adding double dedicated tracks. Any implementation based on existing rail lines might be phased to develop infrastructure improvements incrementally, provided the initial planning accommodates the ultimate capacity need. Such infrastructure could be added over time as the service develops.

3.1.2 NEWPORT NEWS TO RICHMOND ROUTE OPTIONS

From Newport News to Richmond, Chapter 2 discussed the development of several conceptual route options, including some that may involve the use of I-64 highway or Norfolk Southern rights of way and/or shifting the Richmond Direct alignment towards the east and north.

However, for the purpose of the Phase 2(B) supplement the goal was to develop an incremental way to exploit the synergies that became apparent as a result of developing the Richmond Direct alignment to Norfolk. By adding a relatively short connecting link to Toano, Peninsula trains could share the Richmond Direct line into Richmond as well as the whole route north to Washington D.C. As such, an option that follows an existing utility line corridor from Roxbury over to Toano (shown in Exhibit 3-2) was chosen for development as a representative route. The other options still remain on the table for consideration during the detailed Tier I Environmental studies that are yet to come.

Exhibit 3-2: Newport News-Richmond Route Assessed for the Engineering Analysis



** Disclaimer: Findings are not construed to be a commitment on the part of CSX to operate additional service or upgrade infrastructure.*

As can be seen in Exhibit 3-2, the Peninsula representative route includes three segments.

- **Richmond Direct Segment 1: Richmond to Roxbury:** This first segment is a part of the Richmond Direct alignment to Norfolk, so infrastructure assumptions along that segment are developed as part of the Norfolk route option. Peninsula diesel trains could use this track (130-mph on diesel power, not using the overhead electrification) for no additional capital cost.
- **Toano Connector Segment 2: Roxbury to Toano:** This segment would be a greenfield connector following an electric utility right-of-way over to Toano. Although new dedicated track will be constructed the segment will not need to be electrified. This will be developed as part of the Peninsula route option.
- **Shared CSX Peninsula Segment 3: Toano to Newport News:** This segment from Toano to Newport News would follow the existing CSX rail line and be limited to a 90-mph top speed. This will be developed as part of the Peninsula route option.

As a result Segment #1 is developed as part of the Norfolk service. Only segments #2 and #3 are solely associated with developing Enhanced Passenger Rail on the Peninsula.

3.1.4 FREIGHT RAILROAD PRINCIPLES

Any shared use of freight rail corridors or tracks must respect the need for continued safe and economical rail freight operations. At a minimum, it is intended that the freight railroads must be able to operate their trains as effectively as they could if passenger service did not exist. Beyond this, it is desirable to actually create benefits for freight rail service if possible while developing the infrastructure needed to support passenger services. This has been done in Virginia, for example through development of the NS Heartland

Corridor and CSX National Gateway. These projects were justified based on their economic and job creation benefits. Freight railroads must retain their ability not only to handle current traffic, but also to expand their own franchises for future traffic growth.

As such, both CSX and Norfolk Southern have established “Letters of Principle” to provide guidance to passenger rail planners. The purpose of the principles is to protect the safety of railroad employees and communities, service to freight customers, and the right-of-way and land needed to fulfill the railroads’ freight transportation mission. However, Norfolk Southern acknowledges that each passenger proposal is unique, so NS' application of the principles to particular proposals will often be unique as well.

With regard to high speed rail (HSR) service and corridors, Norfolk Southern’s principles point out that the following special considerations are necessary:

- Norfolk Southern will work with planners to insulate high speed rail corridors from interference with and from NS freight corridors.
- On Norfolk Southern, passenger trains operating in excess of 79 mph require their own dedicated tracks, although CSX will share tracks up to 90 mph. On Norfolk Southern, Trains operating in excess of 90 mph require their own private right-of-way.
- Where higher -speed trains share tracks with conventional freight trains, those high speed trains will not be able to exceed 79 mph. Where shared track is concerned higher speed trains must meet the same safety standards as conventional freight trains.

CSX's principles[2] require that:

- Access to host railroad track and property must be negotiated between the parties on a voluntary basis.
- Designing for safety is paramount and separate tracks will be needed to segregate freight and conventional passenger rail from high speed rail at sustained speeds in excess of 90 mph.
- Service to rail freight customers must be reliable and protected and cannot be compromised; adequate capacity must be maintained and, in some cases, built to address future freight growth.
- New infrastructure design must fully protect the host railroad's ability to serve its existing customers, both passenger and freight, and locate future new freight customers on its lines.
- Host railroads must be adequately compensated, especially in regard to the significantly higher maintenance cost associated with enhanced track infrastructure that will be required for high speed rail.
- Host freight railroads need to be fully protected against any and all liability that would not have resulted but for the added presence of high speed passenger rail service.

Norfolk Southern requested that this draft report make clear (See Appendix H) that all high speed (above 90 mph) portions of the route would be constructed off of Norfolk Southern right-of-way, so any high speed route should assume at least a 50-foot separation between high-speed and Norfolk Southern freight tracks. As a result, in this study where speeds greater than 90-mph have been proposed, it has been assumed that a public entity would purchase a strip of land parallel to the existing rail right-of-way.

At present the passenger proposals laid out here are still un-negotiated, un-funded and at a feasibility level. The required capacity analysis for shared track segments has yet to be done. As a result, the work is not yet at a detailed enough level to satisfy the needs of the freight railroads. It is understood that in following detailed engineering and environmental studies, the details of integrating the proposed passenger operations with freight operations will be subject to close negotiations with the railroads. This will include detailed engineering and operation studies. The final capital plan and capital costs for shared segments will eventually need to be worked out in negotiations with the freight railroads.

In the meantime, this report contains preliminary data which is subject to review, verification and approval by both CSX and Norfolk Southern Railroad. As of the date of this report, this review process has not taken place. Findings are not to be construed as a commitment on the part of either CSX or Norfolk Southern to operate additional service.

3.2 Segment by Segment Analysis – Norfolk to Richmond

The following subsections will address environmental and engineering conditions existing along each route segment from Norfolk to Richmond. A Norfolk Harbor Park to Suffolk segment using the "V"-Line is common to all alternatives.[3] After that, individual segments are assembled to develop the full route for each of the developed Options 1A, 1B, 2A, 2B and 3.

[2] See: http://pt.slideshare.net/HRPartnership/passenger-trains-for-va-peninsula-csx-7-17-09

[3] A potential alternative rail routing between South Norfolk and Suffolk could follow the existing Norfolk Southern main line. Existing Amtrak service uses this line, but studies dating back at least as far as 2002 have argued that the "V-Line" offers a better opportunity to develop a dedicated passenger rail alignment. Using the "V-Line" avoids a major rail freight yard at Portlock, and also avoids the need for adding tracks to Norfolk Southern's main line across the Dismal Swamp. DRPT's Hampton Roads Tier I EIS assumed that the "V-Line" would be used, and this recently was granted an FRA Record of Decision. However, even while the "V-Line" does presents an obvious opportunity to develop a dedicated

3.2.1 NORFOLK HARBOR PARK TO SUFFOLK - EXISTING RAIL SEGMENT

This segment of existing urban rail corridor is common to all options. Although the proposed "V"-Line alignment is fairly straight, it does include some speed restrictions as well as proposed station stops at Bowers Hill and Suffolk that will limit train speeds. It is proposed that the "V"-line and Portsmouth Subdivision right-of-way be purchased from NS and CSX from South Norfolk through Suffolk, subject to an easement for continued freight operations. From the Harbor Park station through South Norfolk to the lift bridge over the south branch of the Elizabeth River, a 79 mph design standard will suffice and produces the best compatibility with shared freight operations. From the Elizabeth River lift bridge to Kilby (west of Suffolk), it is suggested that the alignment be developed to 110 mph standards which is still compatible with shared freight operations and allows grade crossings. This speed option can be considered based on the proposed purchase of this right-of-way to be developed into a dedicated passenger alignment.

For speeds up to 110 mph, special highway grade crossing treatments (quad gates) are needed, but grade separations are not required. This does not preclude consideration of grade separations for this segment, but since they are not required by regulation, each grade separation should be individually reviewed and justified on its own merits.

Since the existing Amtrak service could also use the Suffolk to Norfolk improvement, any upgrades made for developing the "V"-line from Suffolk to Norfolk would have independent utility. Improvements to this segment could therefore proceed incrementally in advance of development of the full High Speed rail project and would in fact help lay the groundwork for bringing High Speed rail into Norfolk.

NORFOLK HARBOR PARK TO SOUTH NORFOLK

From Norfolk Harbor Park to South Norfolk, the alignment follows the existing Norfolk Southern double tracked main line. The recommendation would be to add one track to the existing right-of-way, so the line would be completely triple tracked from Harbor Park to the junction of the "V-Line" at South Norfolk. These tracks could all be shared with freight trains, but in fact the westernmost track would be primarily dedicated to passenger trains; while the two eastern tracks would maintain the capacity of the existing freight line. This 2.2 mile segment would be operated at 79 mph or less and due to right-of-way restrictions, should be constructed on conventional 14'-15' track centers. It has 6 grade crossings.

Norfolk Southern bridges 5 and 5A cross the east branch of the Elizabeth River just south of the Harbor Park station. Bridge 5 carries the two current Norfolk Southern main tracks across the river. Beside it, Bridge 5A is currently out of use but according to the DRPT Hampton Roads EIS has been maintained in serviceable condition, and could be reactivated just by reconnecting the tracks. No special maintenance issues have been noted in previous studies regarding this bridge. This should be assessed in the next phase of work to ensure not only safety, but also reliable operation of the bridge after it is restored to service. Starting just east (north) of the Harbor Park station, a third track would be added along the east side of the right-of-way, crossing Bridge 5A. This new track would become the new eastbound freight track; the existing tracks on Bridge 5 would be used for westbound freight and passenger trains, respectively.

Old track charts suggest at one time a former third track across Bridge 5A continued south to "NS Junction" where the Norfolk Southern main connects to the Norfolk & Portsmouth Belt line, about 1.4 miles south of Harbor Park station, directly underneath the US-460 highway overpass. A section of this

passenger alignment, it is still necessary to ensure that a sufficient level of environmental documentation exists to support the formal screening of the Norfolk Southern existing rail alternative. It is recommended that this issue be discussed with FRA to determine what level of analysis of the existing NS main line will suffice to withstand any potential legal challenges. This will also be very useful to serve as public outreach material to explain why developing the "V-Line" as a dedicated passenger rail corridor makes sense.

former third track still remains as a short siding just north of "NS Junction." It is assumed that this siding would be subsumed into the 3rd track restoration along the east side of the right-of-way. From Harbor Park to "NS Junction," this section will be estimated as 1.4 miles of new track on existing roadbed and also includes the base cost for one station. (This provides an allowance for expanding the capacity of the existing terminal station at Harbor Park.)

South from "NS Junction" to the V-Line at South Norfolk, a distance of 0.8 miles, the corridor passes through a densely built up urban residential area on a narrow right-of-way. Based on the position of fence lines, it would appear that the existing double track is positioned within an approximate 90' wide right-of-way, but some existing buildings come right up to the edge of the property line. As shown in Exhibit 3-3, it appears that existing tracks are not quite centered within the right-of-way, rather they seem to be shifted a little closer to the east side of the right-of-way. As a result, south of the US-460 overpass, there is more room to add a new track on the west side than on the east side. There is no evidence that a third track ever existed in this area, so it will be costed as 0.8 miles of new track on new roadbed (15' fill height) on 14-15' track centers. This new track added on the west side would connect directly into the "V-Line" at South Norfolk.

Exhibit 3-3: Norfolk Southern Asymmetrical Right-of-Way between NS-Junction and South Norfolk

SOUTH NORFOLK TO ALGREN

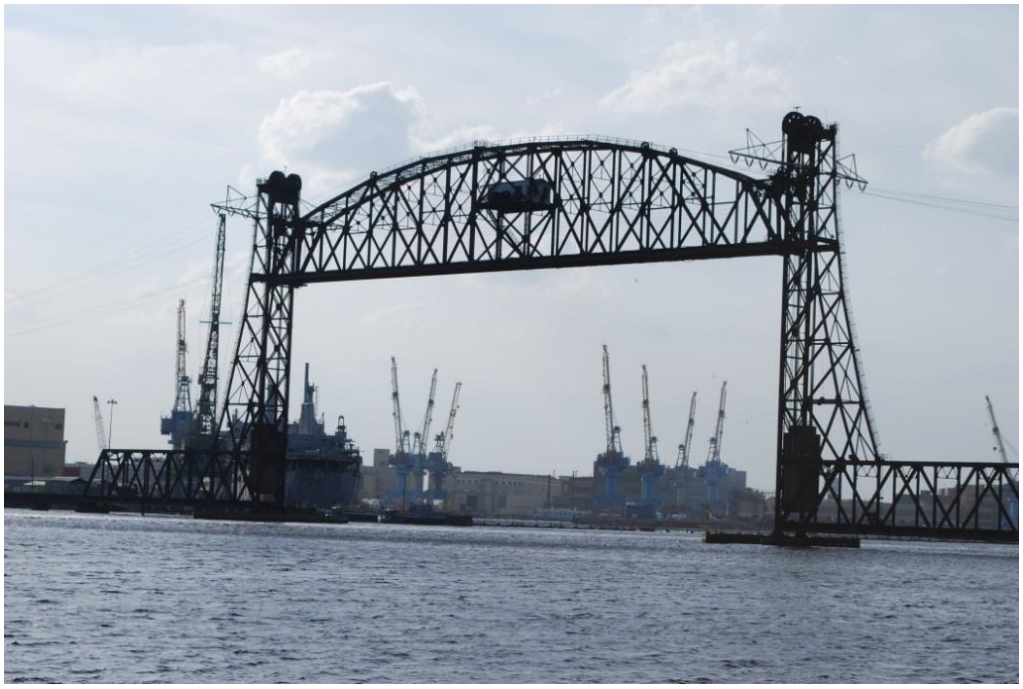
South Norfolk is where the "V" Line diverges from the main line just north of Norfolk Southern's Portlock Yard. Algren is where the "V"-line formerly crossed the CSX Portsmouth Subdivision at grade. Geographically the Algren rail junction lies just south of the Hampton Roads Executive Airport. From South Norfolk to Algren the former Virginian tracks are still in place; west of Algren the tracks have been removed. The distance from South Norfolk to Algren is 10.3 miles. The segment has 13 grade crossings and includes the cost for one station at Bowers Hill.

From South Norfolk, the "V-Line" heads west through a residential neighborhood on an approximate 100' right-of-way. It passes under US-460 and I-464 and emerges into an industrial and wetland area on the east bank of the south branch of the Elizabeth River. Crossing the Norfolk & Portsmouth Belt branch line at grade, the alignment spans the Elizabeth River on a large single track lift bridge (Exhibit 3-4). No special maintenance issues have been noted in previous studies in regard to this bridge. This should be

assessed in the next phase of work to ensure not only safety, but also reliable operation of the bridge in daily service.

The distance from South Norfolk across the bridge to the west bank of the Elizabeth River is 1.9 miles. Because of the relatively short length of this segment, single tracked bridge structure, freight train sharing, curves and urban environment, it is assumed that the line will be operated at 79 mph and remain single track from South Norfolk to the river bridge. It will be estimated as 1.9 miles of single new track on existing roadbed. On the west bank of the Elizabeth River, Norfolk Southern serves a Giant Cement import pier[4]. This pier has a permitted throughput capacity in excess of 450,000 tons, or approximately 4,000 railcars annually.

Exhibit 3-4: "V" Line Lift Bridge over the South Branch of the Elizabeth River



Currently, the "V" line continues west in active service for another 4.5 miles beyond the cement facility to the Cavalier Industrial park, but carries only very light industrial traffic. Beyond the industrial park, the "V"-line tracks remain in place but out of service for another 3.9 miles to Algren, the junction with the CSX Portsmouth Subdivision. There is a section of about 0.6 miles along Old Virginia Road, and 1.9 miles along Denver and Taft drives where residential development tightly hugs the rail right-of-way and will likely need sound wall protection. The proposed Bowers Hill station lies in the middle of this out-of-service segment.

From the Elizabeth River Bridge to Algren, some portions of "V Line" right-of-way appear to be wide enough and already graded for double track. However, there is no evidence from the historical track charts that double track ever existed along this section of "V Line." Therefore the "V Line " upgrades will be estimated as 8.4 miles of single track on existing roadbed, along with 8.4 miles of second new track on

[4] See http://www.prnewswire.com/news-releases/giant-cement-holding-inc-acquires-deepwater-import-terminal-in-portsmouth-va-74506237.html

new roadbed with approximately 15' average fill height. It will include 2.5 miles of sound wall protection for the adjoining residential development.

For supporting the 110-mph upgrade west of the Elizabeth River bridge, it is proposed to purchase the whole "V" Line from South Norfolk to Algren, which has remained intact with a track on it the whole way. The purchase would be subject to an easement for continued rail freight service. A placeholder of $1.09 million per mile for the cost of this "V"-Line track from South Norfolk to Algren and right-of-way purchase has been estimated based on the recently-completed line sale in Michigan. However, it should be noted that the Michigan track was signalized, in active passenger service and was in much better condition than the "V"-line track. The actual purchase price will be subject to negotiations between the parties.

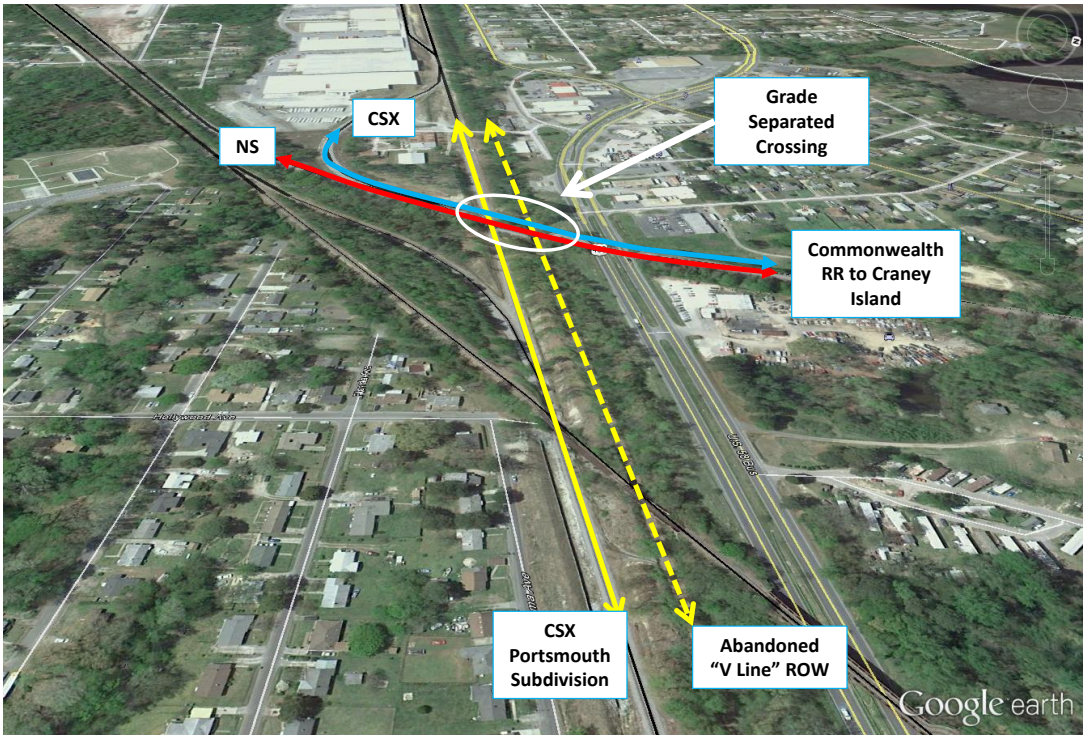
ALGREN TO EAST SUFFOLK

Algren is where the Norfolk Southern "V"-line formerly crossed the CSX Portsmouth Subdivision at grade just south of the Hampton Roads Executive Airport. East Suffolk is a rail junction where the Commonwealth Railway to Norfolk International Terminals, and a short remnant of a CSX branch line, both pass over and connect with the CSX Portsmouth Subdivision. At this location, a CSX industrial spur also connects south to several industries and provides a possible connection to the Norfolk Southern main line. See Exhibit 3-5.

The DRPT Tier I FEIS has assumed that the "V"-line tracks would join CSX at Algren so passenger trains could share the CSX Portsmouth Subdivision from Algren through Suffolk to Kilby. However, this study makes a different set of assumptions for separating freight trains from passenger trains as much as possible. This separation is needed to guarantee CSX unfettered access to the Portsmouth and APM Terminals, as well as to develop a dedicated passenger infrastructure on a geometrically high quality alignment.

Instead of sharing the CSX track here, it is proposed to construct new 110 mph dedicated double-track along the parallel former Virginian right-of-way. From Algren to East Suffolk, the abandoned "V-Line" right-of-way closely parallels the CSX Portsmouth subdivision (about 100' on the north side.) The distance from Algren to East Suffolk is 6.9 miles. The segment has 9 grade crossings. Since the "V-Line" right-of-way has been legally abandoned it has been estimated as a suburban land transaction at a rate of $35 thousand per mile. However, the actual purchase price will be subject to negotiations between the parties. For completely separating passenger trains from the CSX freight line, a grade separation at Algren would be needed. A placeholder of $50 million has been included for grade separating the rail crossing at Algren.

Exhibit 3-5: Commonwealth Rail Crossing at East Suffolk



The first 4.5 miles west from Algren cross the Dismal Swamp with wetlands areas close along the CSX right-of-way on the south side. Beyond the Dismal Swamp there is an industrial siding serving an asphalt and concrete ready-mix facility, also on the south side of the CSX tracks. From this point the CSX and "V-Line" right-of-way continue to parallel one another for the remaining 2.4 miles to East Suffolk. Housing development spreads north from Washington Street, adjoining the CSX alignment on the south side for the last mile into Suffolk.

Because of the wetland areas, ready mix plant and housing development all on the south side of the existing CSX track, it would appear that any new track should be added on the north side. In this area, the parallel "V-Line" right-of-way already exists and is graded on the north side. As a result, would appear to make sense to reclaim the "V-Line" right-of-way, so this segment will be estimated as 6.9 miles of double track on new roadbed. This is sufficient for establishing a dedicated passenger line that is totally separate from the CSX Portsmouth Subdivision. It will include 1.0 miles of sound wall protection for adjoining residential development on the east end of Suffolk.

EAST SUFFOLK TO KILBY

Previous studies (such as the 2002 *Richmond to South Hampton Roads High-Speed Rail Feasibility Study*[5]) have all assumed that passenger trains would use the CSX Portsmouth Subdivision through downtown Suffolk to Kilby, a distance of 3.9 miles. It is clear that the CSX Portsmouth Subdivision provides the highest quality passenger alignment through Suffolk. The alignment is straight, it avoids the sharp curves that would otherwise be needed to connect from the "V"-line over to the Norfolk Southern main line

[5] The DRPT report suggests that the CSX Portsmouth subdivision be developed for rail passenger service but assumes only a single track line, shared with freight trains, see: http://www.drpt.virginia.gov/studies/files/SHRExecutiveSummary.pdf

through town, and following the CSX Portsmouth Subdivision through town would fully separate passenger trains from the heavy freight trains that are operating along the Norfolk Southern alignment.

However, given the recent increase in CSX double stack traffic,[6] as well as the higher frequencies of passenger trains proposed by the current study, it is not realistic to assume that High Speed passenger trains can use the CSX Portsmouth Subdivision without adding enough capacity for CSX double stack trains to operate to/from the Virginia ports in an unfettered manner. Due to right-of-way limitations through downtown Suffolk it will be difficult to add enough tracks along the CSX alignment to provide dedicated infrastructure for both freight and passenger trains. Therefore, an alternative solution could be to develop a consolidated freight corridor through Suffolk, as was originally proposed by the Suffolk Rail Impact Study[7] as a possible grade crossing mitigation measure. As shown in Exhibit 3-6, a consolidated freight corridor would effectively remove CSX trains from the Portsmouth Subdivision through downtown Suffolk by consolidating all freight on the Norfolk Southern right-of-way through town.[8] This would allow cost effective grade separation of highway crossings on the freight line, while the Portsmouth Subdivision could be repurposed into a dedicated passenger alignment.

Exhibit 3-6: Proposed Consolidated Freight and Passenger Routings through Suffolk

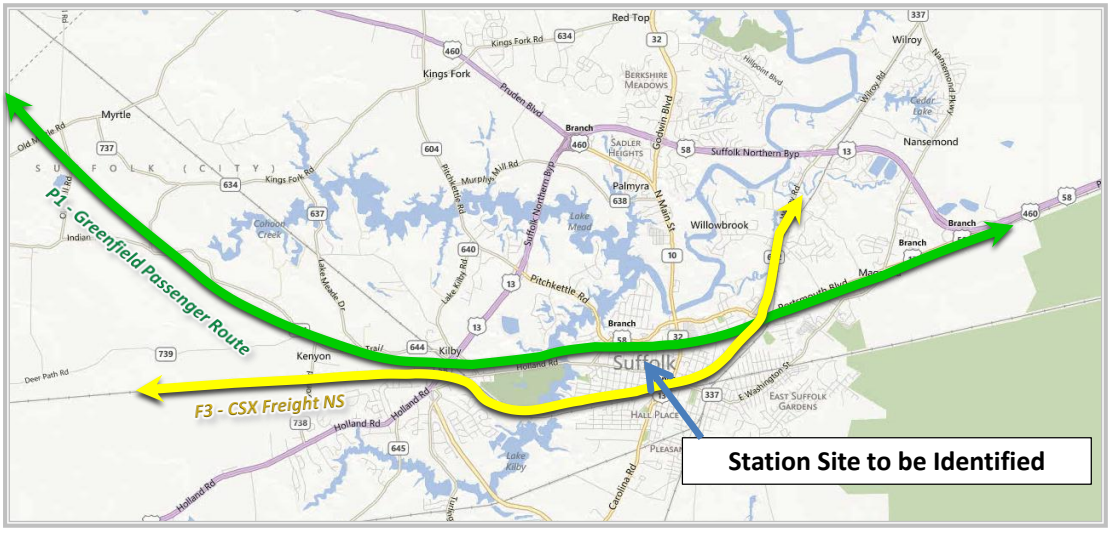


Exhibit 3-6 shows a "balloon" track connection for freight trains between the Norfolk Southern main line and CSX's Portsmouth Subdivision at Kilby. This would be in the opposite quadrant from the "balloon" connection that the DRPT EIS proposed for passenger trains at Kilby. This connection would enable CSX trains to reenter their own line while staying on the north side of the Norfolk Southern alignment, without needing to cross any of the Norfolk Southern tracks. At the same time, rather than continuing on the Portsmouth Subdivision west of Constance Road (US 58), the passenger alignment could shift to the former Virginian right-of-way. This would avoid any conflicts with the CSX track connection at Kilby,

[6] Due to the Panama Canal expansion and CSX's own National Gateway project (http://www.nationalgateway.org/projects/project/548), CSX double stack traffic has substantially *increased* on this line segment through downtown Suffolk. Recently, for consolidating blocks of on-dock rail container traffic, CSX added a support yard at Kilby, just west of Suffolk. The Virginia Port Authority recently opened a new port at Norfolk International Terminal. Both Norfolk Southern and CSX access this port over the Commonwealth Railway, which joins the CSX and NS main lines at East Suffolk. CSX still has substantial local freight business in Portsmouth and continues to serve the APM Container terminal as well.

[7] See: http://www.hrtpo.org/uploads/docs/SuffolkRailReport.pdf

[8] This could be done by adding a third track along the north side of the existing NS rail corridor. This third track could be functionally independent of Norfolk Southern operations and may be placed under CSX dispatch control. Alternatively, CSX stack trains might be shifted away from downtown Suffolk altogether, by using Norfolk Southern's parallel rail line from Suffolk to Franklin. This could allow abandonment of the CSX Portsmouth Subdivision from Kilby to Franklin, but would require constructing a new rail connection in Franklin.

since CSX would use the existing Portsmouth Subdivision bridge under the Norfolk Southern main line, while the passenger service could use the former Virginian underpass. This track configuration could effectively separate CSX freight, NS freight and passenger trains onto their own tracks.

While this could develop an essentially dedicated infrastructure for passenger trains between Suffolk and Norfolk, the engineering design should not preclude operation of freight trains.[9] Therefore it is recommended that the infrastructure from Kilby to Norfolk Harbor Park should accommodate freight railroad clearance and other engineering requirements. For example, if electric catenary were installed, the 20' 6" freight railroad clearance envelope should be respected, so as not to preclude the operation of double stacked trains under the wire through downtown Suffolk or east of Suffolk.[10] See Exhibit 3-7.

Exhibit 3-7: CSX Double Stack Train under SEPTA Catenary at West Trenton, NJ[11]

The costs for the East Suffolk to Kilby segment have been revised and slightly increased from the original Phase 2(B) study to reflect the cost of fully separating CSX freight from passenger trains all the way from Algren to Kilby. The costing has also been made more specific in regard to costs for right-of-way acquisition and specific engineering improvements associated with the proposal. Costs have been developed both for improving the proposed passenger alignment (CSX Portsmouth Subdivision) and also for developing the consolidated grade crossing project. Inasmuch as the original Phase 2(B) study included a "placeholder" for Suffolk freight mitigation needs, this new cost although it has been revised

[9] For example, CSX will want to continue to serve its customers on the Portsmouth Subdivision in downtown Suffolk, will probably want to retain rights to operate some trains through downtown Suffolk, will want to be able to continue accessing its customers and port facilities in Portsmouth, and its interchange with the Norfolk & Portsmouth Belt Railroad. Similarly, Norfolk Southern will want to continue serving customers on the "V-Line," and may also benefit from the ability to divert freight trains onto the "V-Line" if any emergency or blockage were to disrupt its main line, or during track maintenance activities.

[10] The European standard catenary height is 16-19 feet above the rail which is not high enough to accommodate double stack trains under the wire. The Amtrak standard is 22 feet, although it is lower in some places. High speed lines tend to use lower catenary since this promotes maximum stability of the pantograph power collector at high speeds although in France, for example, the wires are still high enough to permit operation of double-decked TGV trains. However in terminal areas where train speeds are reduced, the pantograph can extend farther up to contact the wire. Pantograph stability at 110-mph is not a serious concern.

[11] See: http://www.railpictures.net/viewphoto.php?id=346306&nseq=6

upwards still contains a number of uncertain elements, such as the costs for right-of-way acquisition, and for highway grade separations along the consolidated freight corridor that might be proposed by the City of Suffolk, that have not been fully assessed or included here. This needs more detailed examination by a future study.

First, for developing the CSX Portsmouth Subdivision into a double tracked, dedicated passenger alignment from East Suffolk to Kilby, it is assumed that this segment will be developed to 110-mph standards. It has 5 grade crossings, and will be estimated as 3.9 miles of new single track on existing roadbed, and the second track 3.9 miles on new roadbed with approximately 15' average fill height. The cost for one station at Suffolk will also be included in the cost for this segment. The cost assumes that the former Virginian right-of-way will be used between Algren and East Suffolk, but that soon after the line passes underneath the Commonwealth Railway overhead bridge the alignment will shift gradually south (by about 100') and transition onto the CSX right-of-way through downtown Suffolk.

For supporting the development of a dedicated passenger route through downtown Suffolk, it is proposed to purchase the short segment of CSX Portsmouth Subdivision from East Suffolk to Kilby and construct the consolidated freight corridor, for shifting CSX trains to the north side of the Norfolk Southern line. This track and right-of-way purchase would be subject to an easement for continued rail freight service. A placeholder of $1.09 million per mile for the cost of this Portsmouth Subdivision track has been estimated based on the recently-completed Norfolk Southern line sale in Michigan. However, it should be noted that the Michigan track was signalized, in active passenger service and was in much better condition than the Portsmouth Subdivision track. The actual purchase price will be subject to negotiations between the parties especially since it is proposed to provide replacement capacity for the bypassed line segment.

Second for developing the consolidated freight corridor, an additional sum has been included for constructing a third track along the Norfolk Southern right-of-way. This assumes that CSX trains coming off the Commonwealth Railway instead of turning onto the CSX line will just continue south to the NS main line at Liberty Street. A third track would be added on the north side of the Norfolk Southern corridor for a distance of 4.0 miles from Liberty Street to Kilby, including the length of the balloon track connection back to the CSX line west of Kilby. The costs for this segment also include an allowance for interlockings and signal systems cost.

Development of a dedicated "V"-line access into downtown Norfolk is a priority of both the DRPT FEIS as well as a clear prerequisite for the implementation of High Speed rail as well as for enhancement of the existing Amtrak service. The segment includes the proposed Bowers Hill station which will be developed into an important suburban stop and economic development center. Therefore, it is recommended to start engaging in right-of-way discussions with CSX and Norfolk Southern, as well as to advance the Suffolk Consolidated Freight Corridor project at the earliest possible opportunity. This can be done in advance of the main High Speed rail effort since the Norfolk to Suffolk segment has independent utility.

3.2.2 SUFFOLK TO PETERSBURG – DEDICATED TRACK ALONG NORFOLK SOUTHERN (OPTION 1B AND 2B)

The possibility for adding dedicated high speed tracks to the existing Norfolk Southern alignment has been considered from Suffolk to Petersburg as part of Options 1B and 2B.

Normally, geometric issues would prevent operating a true high speed service along an existing rail right-of-way, but in this highly unusual case the existing alignment is arrow-straight from Suffolk to the outskirts of Petersburg. This suggests at least the conceptual possibility for developing a high speed rail service, so a preliminary assessment has been developed. This option is considered as a "Greenfield"

alternative, since it is characterized as a dedicated segment of all-new, 220 mph capable high speed rail alignment which may or may not be co-located within an existing railroad right-of-way*.

KILBY TO BAKERS POND

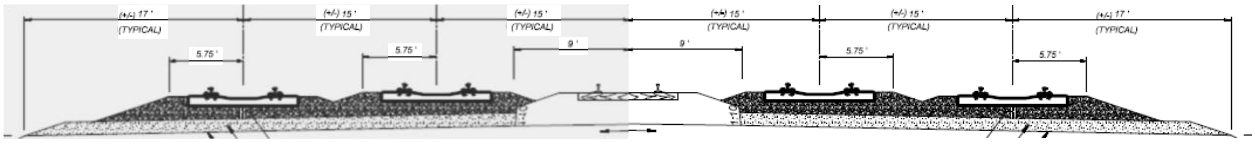
For option 2B, a possible connection from Norfolk Southern to I-295 would diverge at Bakers Pond -- approximately 0.3 miles east of the Route 156 grade crossing, about halfway between Poe and Disputanta. The distance from Kilby to Bakers Pond south of Route 156 is 46.1 miles. Continuing along the NS main line and Petersburg Belt Line, the distance from Bakers Pond to the junction of the Collier connection south of Petersburg is 9.3 miles.

In terms of the potential feasibility of a high speed option following the Norfolk Southern rail corridor, for development of reasonable alternatives planners will be constrained by the National Environmental Policy Act (NEPA), particularly Council of Environmental Policy guidance[12] which states:

> *If a proposed action is to be located in a wetland or significantly encroaches upon a floodplain, a finding must be made that there is no practicable alternative to the wetland take or floodplain encroachment. Any alternative that does not meet the need for the action is not practicable. If the action's purpose and need are not adequately addressed, specifically delineated, and properly justified, resource agencies, interest groups, the public, and others will be able to generate one or possibly several alternatives that avoid or limit the impact and "appear" practicable. A well-described justification of the action's purpose and need may prevent long and involved negotiations or additional analyses demonstrating that an alternative is not practicable.*

It is clear in terms of alternatives being developed, that minimizing wetland impacts as well as property takes will be key to the environmental competitiveness of any alternative. For development of a Norfolk Southern corridor alternative, it became apparent that only a "Narrow Footprint" option could be economically and environmentally competitive to the other Greenfield options. This assumes placement of four tracks within a 100'-120' right-of-way footprint, as shown in Exhibit 3-8, with nominal track centers of 15', two passenger tracks would be separated from the two freight tracks by a 30'-50' track center spacing. Norfolk Southern has requested the wider spacing of 50'. This footprint leaves enough space for a fifth or sixth track in the middle, and three feet buffer on each edge of right-of-way.

Exhibit 3-8: 100′ Right-of-Way Footprint for a Passenger and Freight Rail Corridor



The potential viability of the narrow footprint option derives directly from the issue of wetlands. According to the GIS Wetland Shapefiles in Exhibit 3-9, there is an already existing corridor along the Norfolk Southern tracks within which the wetland areas have already been compromised. This corridor appears to vary in width from 75' to 150.' A detailed on-the-ground survey, which was beyond the scope of the current study, would be needed to development a more accurate measurement of the actual conditions.

[12] See: http://environment.fhwa.dot.gov/projdev/tdmalts.asp
*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

The two existing Norfolk Southern tracks require a physical footprint of approximately 50'. However, the existing tracks are not generally placed directly at ground level through wetland areas, rather they are on a fill structure with culverts underneath the track. A minimal 12.5' fill with a 2:1 slope would expand the Right-of-Way footprint to 100' as shown in Exhibit 3-10. A 17.5' fill would expand the Right-of-Way footprint to 120'. If the fill were higher, the footprint would be wider. ***However, by adding retaining walls, the same footprint could accommodate the added passenger tracks without needing to claim any wetlands***. This shows how the proposed four track configuration with a 30' separation could be accommodated within a 100' footprint with a 30' spacing, or a 120' footprint with a 50' spacing, ***so this configuration would appear to require only a minimal need for additional wetland taking.***

Exhibit 3-9: 75'-150' Wetland Corridor along the Norfolk Southern at Zuni

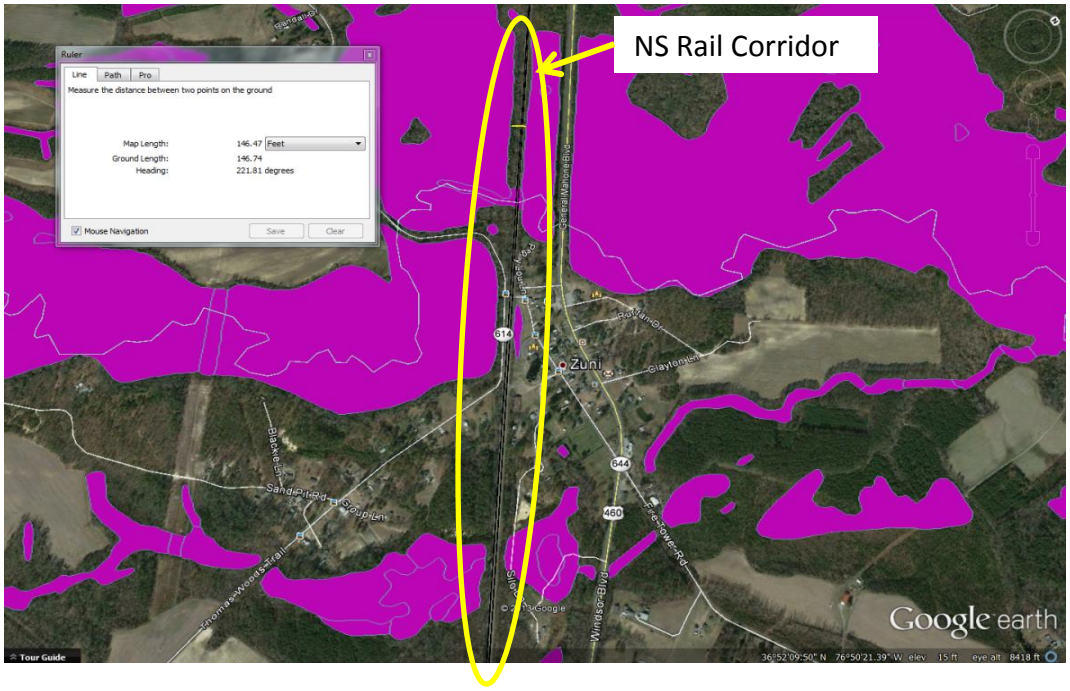
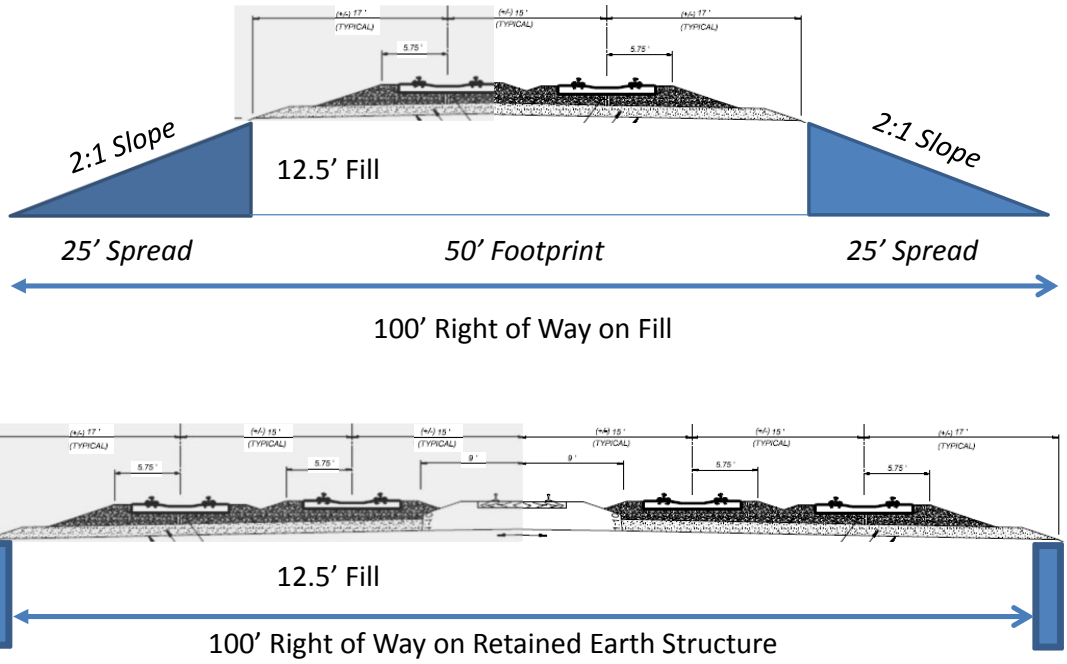


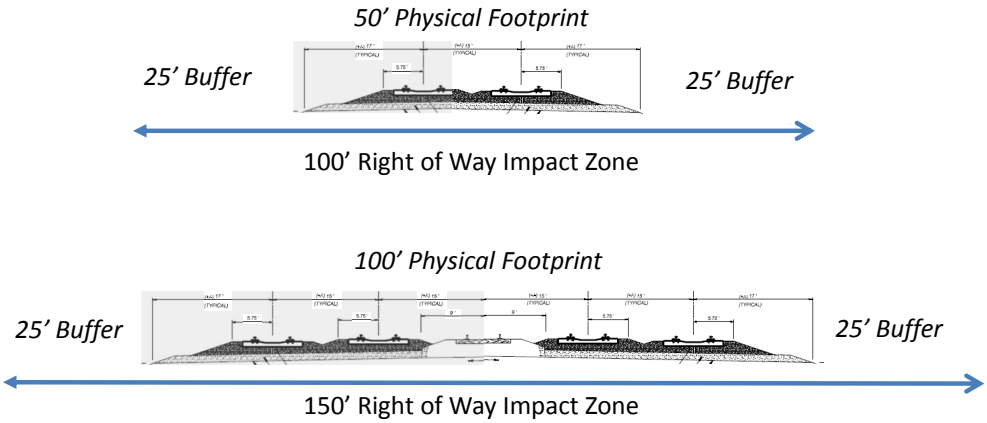
Exhibit 3-10: Fill versus Retained Earth Structure for a 100' Footprint

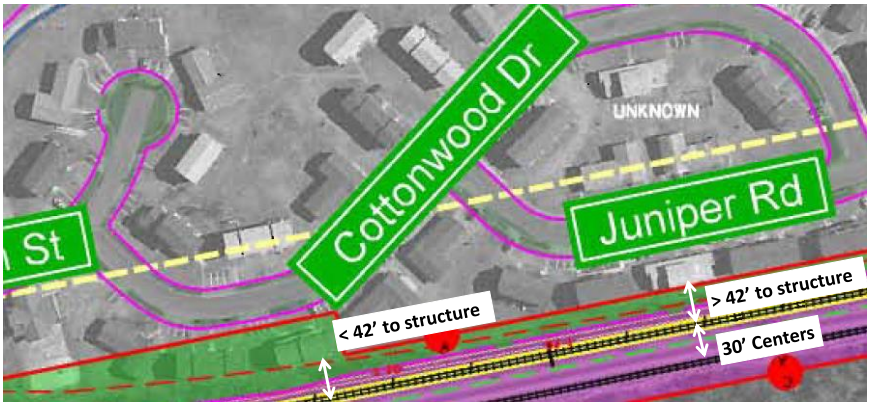


For a "Narrow Footprint" as shown in Exhibit 3-10, it has been estimated that approximately 3 miles of retained earth structure would be needed for areas where the Norfolk Southern corridor passes through wetlands. It is not possible to assess the difference between a 30' and 50' track spacing at the current level of study since this difference is well within the error margin of the available data. A more detailed engineering assessment will be needed to ascertain the difference. In contrast, if a 100' separation were required between the tracks, this would clearly place the new tracks within wetland areas: 6 to 9 miles of bridges may be needed.

The number of property takes depends on the right-of-way width. For consistency in evaluating route alternatives, as shown in Exhibit 3-11, the distance is 17' from the center of the outside track to the edge of the right-of-way, which is part of the minimum 50' footprint. Beyond this, a 25' buffer has been included.

Exhibit 3-11: Impact Zone for Property Taking Assessment





With a 25' buffer, the minimum distance from the outside track center to the nearest structure is 42'.

- For a new double track line on Greenfield alignment, the physical footprint is 50', but the right-of-way width is 100', consistent with industry standards.[13] This provides a clear buffer zone of 25' on each side of the track.
- For a greenfield double track parallel to existing track on a 30' center, the physical footprint is 100', so the right-of-way width must be expanded to 150' to provide the same 25' clear buffer zone on each side of the track. For a 50' center the physical footprint is 120', so the right-of-way width must be expanded to 170'.[14]
- This right-of-way standard also appears to be consistent with what the SEHSR assumed for its property taking criteria, as shown on the alignment plates through Petersburg.

For a 30' separation between the freight and passenger tracks, approximately 87 property takes would be needed to widen the right-of-way to 150' including a 25' buffer zone on both sides of the track. By comparison, for a 100' separation between freight and passenger tracks, approximately 153 residential or commercial property takes would be needed for a 220' right-of-way. It can be seen that the wide

[13] This is consistent with what California is using for its High Speed rail development project, see http://www.hsr.ca.gov/docs/programs/eir-eis/statewide_techrpt_Ag_farmlands_rpt.pdf, page 3

[14] The width of the current Norfolk Southern right-of-way is not known for sure nor is it necessarily the same everywhere. It is assumed however, that Norfolk Southern already owns at least the 50' of right-of-way that are occupied by its existing tracks, so the land acquisition is 100' width to be added to the corridor. The land acquisition therefore is considered the same as for a new Greenfield corridor on separate right-of-way.

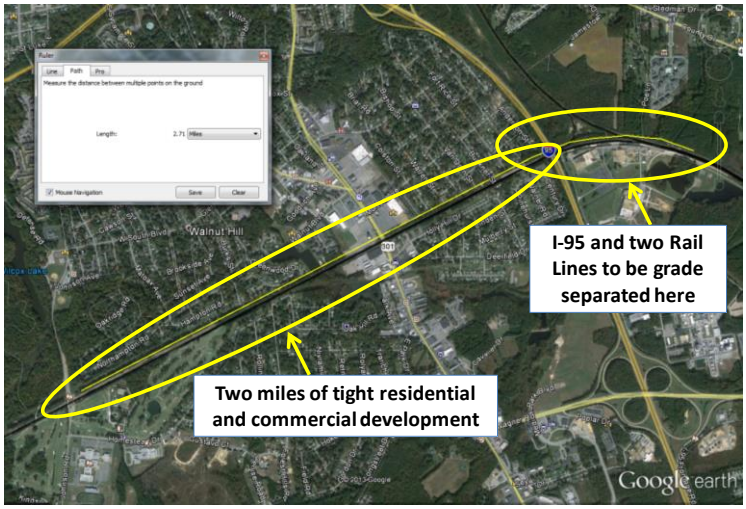
footprint option results in considerably more wetland impact as well as more residential and commercial property impact than would a narrower 30'-50' spacing between the freight and passenger tracks. At the extreme, the level of wetland and property take impacts needed for a 100' track spacing along the existing rail corridor would be enough to render this option uncompetitive with greenfield alternatives from an environmental point of view, whereas it appears likely that an environmentally competitive alternative could be developed based on a 30'-50' track spacing.

Summarizing, the overall segment is 46.1 miles long, of which 3.0 miles is assumed to be new double track on 15' retained earth structure and the balance 43.1 miles double track on new roadbed with approximately 15' average fill height. There are no wetland takes, and 87 property takes. There are 47 grade crossings or existing highway bridges which would all be replaced with new grade separations, averaging approximately one grade separation and 1.9 property takes per mile.

BAKERS POND TO COLLIER CONNECTION

From Bakers Pond, continuing along the Norfolk Southern corridor to CSX connection track at Collier for Option 1B is a distance of 9.3 miles. If the new passenger tracks were constructed on the north side of the alignment, it should be possible to get around the auto facility at Poe without interfering with operations of the auto terminal. However two challenges still remain, as shown in Exhibit 3-12: At the I-95 crossing, the issue is how to get through the rail junction on the north side, without cutting off Norfolk Southern's access to its former main line through Petersburg[15]. Beyond this, residential development tightly hugs the rail right-of-way for the next two miles along the Petersburg Belt Line.

Exhibit 3-12: Challenges along the Petersburg Belt Line


I-95 and two Rail Lines to be grade separated here
Two miles of tight residential and commercial development
Walnut Hill
Google earth

[15] The old main line through Petersburg and Belt Line are single tracked, paired and directionally operated to create a double tracked mainline through the area. There are three possible ways for dealing with this issue:

- One alternative might be to replace the capacity of the Old Main Line by double tracking the entire Petersburg Belt Line; but this would exacerbate the right-of-way issues since four tracks (two freight and two passenger) would be needed east of Collier.
- The conflict could be eliminated by tunneling under the rail and highway junction. The length of tunnel could be short (0.5 miles) with a short box tunnel to get under the east leg of the railroad wye, and a slightly longer tunnel to get under the west leg of the rail wye and I-95. Between the two legs of the wye and on each end of the tunnel depressed open cut structures would be needed on the approaches to the tunnel portals.
- The third alternative would be to fly over the junction on a high elevated structure. The structure would need to be 60' tall to get over I-95, using a 4% maximum gradient the flyover structure would need to be at least 3,000' long. However an additional 1,800' would be needed to cross over the east leg of the railroad wye at Poe.

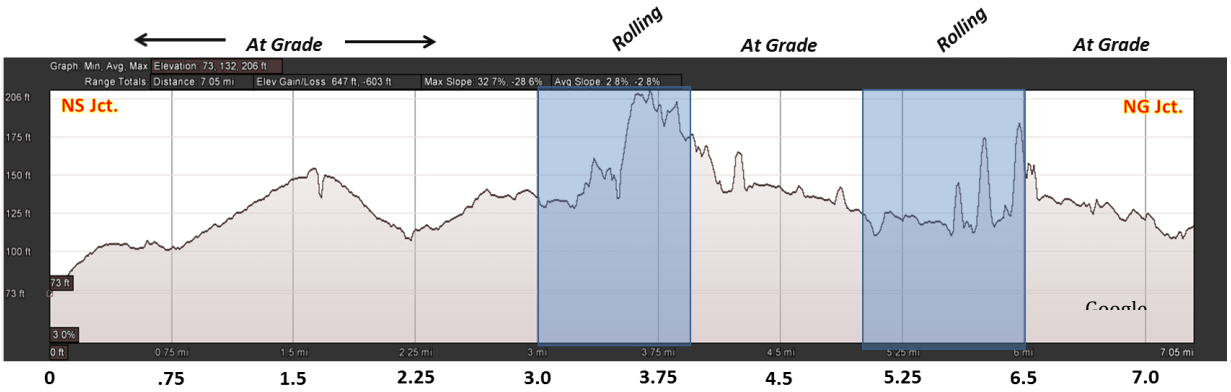
Any of these three alternatives are likely to be expensive. In round dollars a placeholder cost of $100 million (including soft costs and contingency) is likely appropriate for dealing with the combined rail and interstate highway crossing. For a 100' rail corridor footprint, 25 property takings have been estimated over this 9.3 mile stretch. All 9.3 miles are estimated as double track on new roadbed with approximately 15' average fill height. There are no wetland takes, but there are 4 highway crossings that would have to be grade separated in addition to the $100 million placeholder for a rail and highway grade separation at I-95.

Beyond Collier, the alignment would connect to the proposed Southeast High-Speed Rail (SEHSR) improvements through Petersburg to Richmond. The continuation of this route to Richmond will be further discussed as part of the Southern Greenfield alternative 1A.

BAKERS POND TO I-295 VA 646 OVERPASS

Another alternative is to follow I-295 north to Richmond. For option 2B, a 7.2 mile greenfield connection would diverge from the Norfolk Southern right-of-way near Bakers Pond and would head 4.5 miles across open countryside, to enter the I-295 median. It would then continue another 2.7 miles in the I-295 median to the common point where the Northern Greenfield would enter I-295 just south of the VA-646 highway overpass. Exhibit 3-13 shows the elevation profile for this section.

Exhibit 3-13: Elevation Profile, Norfolk Southern to I-295 Connector



As shown in Exhibit 3-13, the cost of the greenfield segment of this connector track is based on 4.5 miles of new double track; 0.4 miles of which are on bridge structure over wetlands and flood plains, 1 mile of which is graded in rolling terrain, and the balance of 3.1 miles at grade. It has 13 roadway crossings, the estimated wetland taking is 0.65 acres, and a 100' right-of-way would require 7 property takings.

Upon reaching I-295, transitioning a rail line into a median strip requires a shallow angle of entry. If the rail line goes over the highway, a long approach structure is needed on either side with a straddle-bent crossing. Putting the rail line over the highway can cost $100 million for a double track rail structure. It is usually less expensive to raise one set of highway lanes to let the railroad pass underneath, as the New Mexico Rail Runner project did as shown in Exhibit 3-14.

Exhibit 3-14: Rail Line Transition to Interstate Highway Median (near Los Cerrillos, NM)

A short box tunnel over the tracks about 0.1 miles long is needed to let the highway lanes pass over. This can be built for $25-50 million. Because of the need for maintaining traffic on the highway it will be estimated at the higher figure of $50 million. The I-295 section is estimated as 2.7 miles of double track on new roadbed, since I-295 is already graded plus a $50 million placeholder for the median strip transition. It includes an allowance for an additional double tracked rail bridge where the I-295 median crosses over VA-634. The continuation of this route beyond the VA-646 overpass to Richmond will be further discussed as part of development of the Northern Greenfield alternative 2A.

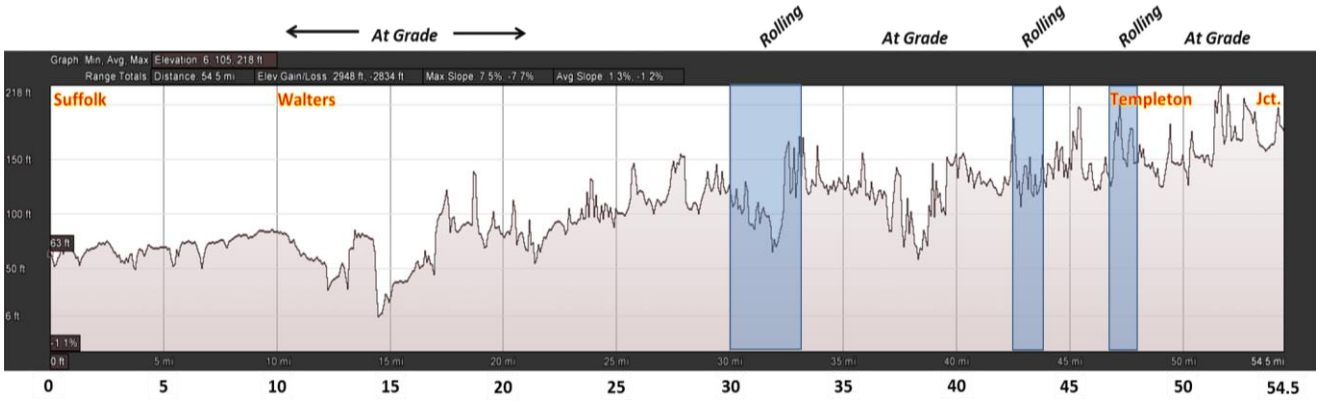
3.2.3 SUFFOLK TO RICHMOND VIA PETERSBURG– SOUTHERN GREENFIELD (OPT 1A)

As previously described, the Southern Greenfield would link Kilby to Burgess, south of CSX's Collier Yard in Petersburg. From Burgess the alignment would follow the SEHSR through Petersburg to Dunlop. At Woods Edge Road, the alignment would leave the CSX rail corridor, cross the James River and utilize an "East Shore Greenfield" through open land to Richmond.

KILBY TO COLLIER

This proposed Greenfield alternative would head west across fairly open countryside 52.3 miles from Kilby to Burgess, where it would join to the proposed SEHSR alignment. It would then follow the SEHSR alignment 2.2 miles north to Collier where the existing Norfolk Southern rail line joins the corridor. Exhibit 3-15 shows the elevation profile for this section.

Exhibit 3-15: Elevation Profile, Southern Greenfield



As shown in Exhibit 3-15, the cost from Kilby to Burgess is based on 52.3 miles of new double track; 2.9 miles of which are on bridge structure over wetlands and flood plains, 5 miles of which are graded in rolling terrain, and the balance of 44.4 miles at grade. There are 100 roadway crossings requiring grade separations. The estimated wetland taking is 25.1 acres, and a 100' right-of-way would require 63 property takings.

The cost for the 2.2 mile section that is shared with SEHSR from Burgess to Collier is based on double tracking the existing SEHSR plan, by utilizing the 30' right-of-way reservation that will already have been provided as shown in the current alignment plates. One additional track would be added between the current SEHSR (single) track and the two existing CSX "A-Line" tracks. Accordingly, 2.2 miles of single track would be added to the existing SEHSR plan. This is estimated as single track on existing roadbed. There are no additional wetland, property taking, or crossing impacts since the SEHSR would provide a fully grade separated alignment and the proposed additional track would be accommodated within the existing planned SEHSR footprint[16].

COLLIER TO WOODS EDGE ROAD

This segment of proposed alignment would share 9.4 miles of right-of-way with SEHSR from Collier to about 0.3 miles north of Woods Edge Road, where the proposed alignment would leave the CSX right-of-way and continue straight onto the East Shore Greenfield. The costing assumptions for this segment are very similar to those for Burgess-Collier since they would utilize the footprints of the improvements that are already planned by SEHSR. In particular, 9.4 miles of single track would be added to the existing SEHSR plan, estimated as additional single track on existing roadbed. There are no additional wetland, property taking, or grade crossing impacts.

The most important added cost along this segment would be the need for a double-tracked Appomattox River bridge, rather than only single track as currently planned by SEHSR. The current Appomattox River

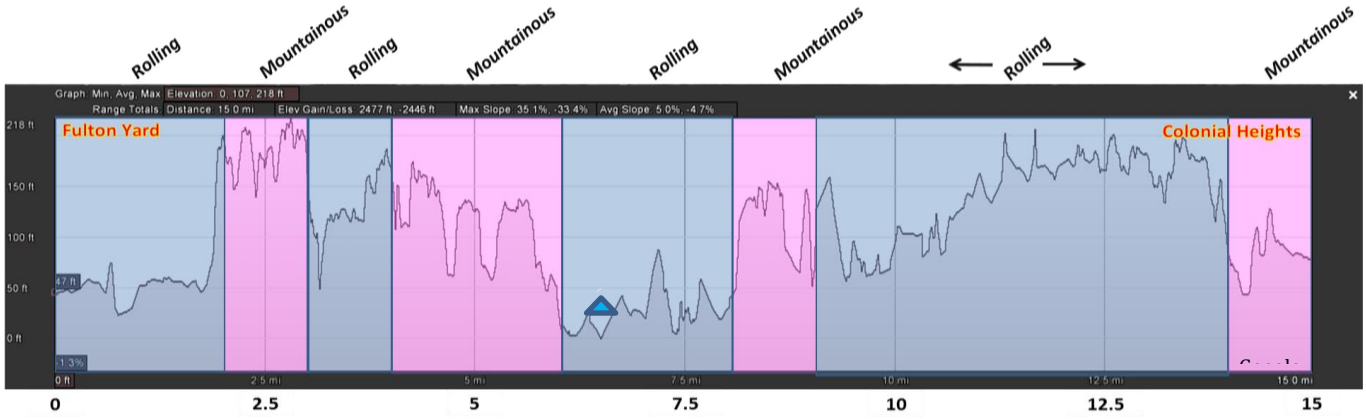
[16] It should be noted that CSX policy allows for co-mingling of freight and passenger trains up to 90-mph on shared track -- and the geometry of this track section won't effectively allow for train speeds much above this 90-mph limit anyway. Therefore as has been discussed previously with DRPT, it is assumed that this existing track can be added within the currently planned SEHSR footprint.

bridge is a roughly 1,300 foot long single tracked structure. By comparison, in 2009 the Union Pacific rebuilt the Kate Shelley High Bridge[17], a double-tracked structure that is almost twice as long and twice as high as the Appomattox River bridge, for $50 million. A placeholder of $25 million is being included in the cost of this segment for the added cost of double tracking the Appomattox River bridge instead of only single tracking the new bridge. A $20 million placeholder is also included here for the development of a high speed rail station at Petersburg.

EAST SHORE GREENFIELD: WOODS EDGE ROAD TO FULTON GAS WORKS

The East Shore Greenfield extends for 14.9 miles from just north of Woods Edge Road on the CSX "A" Line north of Petersburg, to the Fulton Gas Works on the CSX Peninsula Subdivision just east of downtown Richmond. Heading north from Woods Edge Road, it parallels I-95 for about 3½ miles, and then follows an existing CSX branch rail line for another mile or so before the entering new alignment through an industrial area. After crossing the James River it traverses undulating, but relatively open terrain in open land on the east shore of the River to the Fulton Gas Works. Exhibit 3-16 shows the elevation profile for this section.

Exhibit 3-16: Elevation Profile, East Shore Greenfield



From the elevation profile shown in Exhibit 3-16, it is clear that significant grading would be required for constructing the East Shore Greenfield. The cost from Woods Edge Road to the Fulton Gas Works is based on 14.9 miles of new double track; 0.8 miles of which are on bridge structure over wetlands and flood plains, 0.7 miles on a high level bridge crossing the James River, 5 miles of which are graded in mountainous terrain, and the balance of 8.4 miles in rolling terrain. None of the alignment is flat so there are zero miles at grade. A placeholder cost of $350 million is assumed for the high level James River crossing.[18] There are 24 roadway crossings requiring grade separations. Reflecting the relatively rugged nature of the terrain on the east shore of the James River, the estimated wetland taking is only 2.92 acres, and a 100' right-of-way would require only 2 property takings. These savings in right-of-way and wetland impacts may help offset some of the higher grading costs for developing this segment of the alignment.

[17] See: http://www.uprr.com/newsinfo/attachments/media_kit/regional/northern/kate_shelley/fast_facts.pdf
[18] The Varina-Enon Bridge over the James River near Hopewell cost only $36 million to build in 1990. See http://newsgroups.derkeiler.com/Archive/Misc/misc.transport.road/2008-01/msg02557.html The Vietnam Veterans Memorial Bridge on the Pocohontas Parkway cost $111 million in 1996, see http://en.wikipedia.org/wiki/Vietnam_Veterans_Memorial_Bridge_(Richmond).Amtrak's Susquehanna River bridge replacement is currently estimated to cost up to $850 million but would provide *two* parallel double tracked bridges, including a fixed high level bridge. See http://www.nec-commission.com/cin_projects/susquehanna-river-bridge-replacement

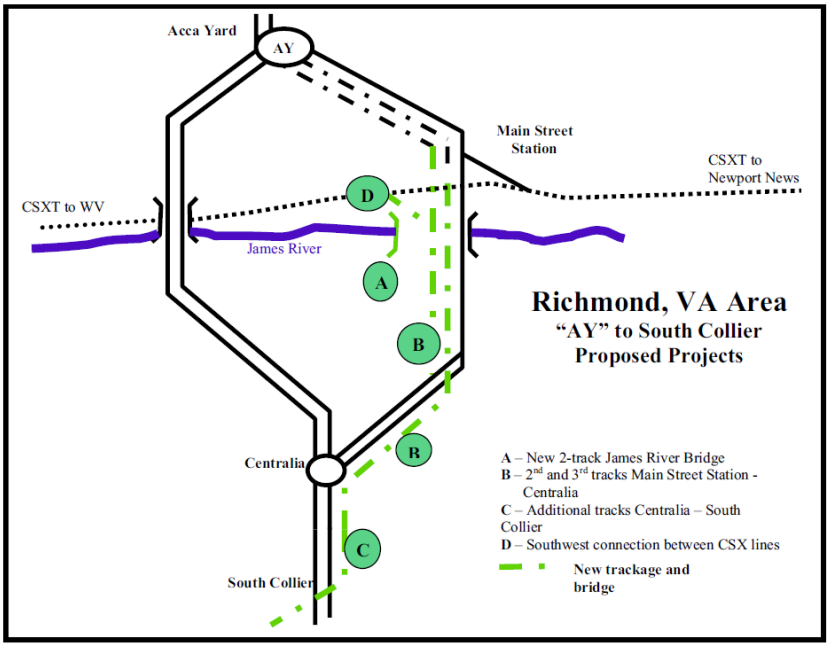
FULTON GAS WORKS TO RICHMOND MAIN STREET

This section of 1.5 miles length would be entirely elevated as it parallels CSX's viaduct from Fulton Yard west to Main Street station. Since the East Shore greenfield approaches from the south and Main Street Station is on the north side of the CSX tracks, the first challenge would be to develop a high level elevated flyover crossing the CSX tracks. Coming down from this flyover, the passenger alignment would land on the north side of the existing CSX viaduct. To avoid the challenges associated with building a bridge structure directly over an active rail freight yard, most likely the flyover would need to be located just west of Fulton yard.

Having transitioned the passenger trains over to the north side of the CSX alignment, if a new structure were actually continued on the north side, this would place the new elevated structure directly over Dock Street. To avoid impacting the historic area, from Fulton Yard to Rivanna Junction it might make more sense to construct a new elevated structure instead on the *south* side of CSX's existing structure, then shift freight trains onto the new structure. Passenger trains could then use CSX's existing viaduct into Main Street station. Doing this would reduce the impact on the historic area.

Double track would be restored on the curving section of viaduct from Rivanna Junction through Main Street station. The limited number of CSX freight trains that run over the Piedmont Subdivision or up to Acca Yard could share a short segment of restored double track on the Piedmont subdivision line. Or, by constructing a new southwest quadrant rail connection at Richmond as proposed by CSX, the number of freight trains that would need to use the track past Main Street may be reduced, see Exhibit 3-17.[19]

Exhibit 3-17: Proposed Southwest Quadrant Freight Connection (Item "D") in Richmond



[19] *U.S. Department of Transportation ,Corridors of the Future Program Application: The Southeast I-95 Corridor*, CSX Transportation, May 2007. See pp. 37-38. http://www.vhsr.com/system/files/CSX+CFP+Submission.pdf *"The proposed southeast connection between the CSXT rail lines will eliminate the need for cumbersome movements of freight trains through the Main Street Station."*

As described previously, the rail infrastructure in this area such as overhead catenary height and platform tracks must be designed to accommodate the requirement for shared freight and passenger use. By doing this it is expected that impacts to wetlands and Richmond historical structures can be avoided.

- For approaching from the East Shore Greenfield, this 1.5 miles will be estimated at the standard rate for elevated double track structure, with an additional $50 million for adding a high level flyover from the south to the north side of the rail alignment.
- For the Richmond Direct and I-295 approaches into Richmond no flyover crossing is needed since these alignments approach along the north side of the CSX right-of-way, so the standard rate for elevated double track structure can used.

3.2.4 SUFFOLK TO RICHMOND VIA HOPEWELL– NORTHERN GREENFIELD (OPTION 2A)

As previously described, the Northern Greenfield would link Kilby to I-295. From Kilby past Zuni the proposed alignment would follow an existing electric utility corridor south of the existing Norfolk Southern tracks[20]. At Zuni, the alignment would swing north across the Norfolk Southern main line to Proctors Bridge Road where the proposed Richmond Direct alternative would diverge. From Proctors Bridge Road to I-295 at Hopewell, the Northern Greenfield alignment to Hopewell would head northwest staying on the north side of US 460. Lining up with I-295, it would enter the I-295 median just south of the VA-646 highway overpass, then continue in the I-295 median to Richmond.

KILBY TO PROCTORS BRIDGE ROAD

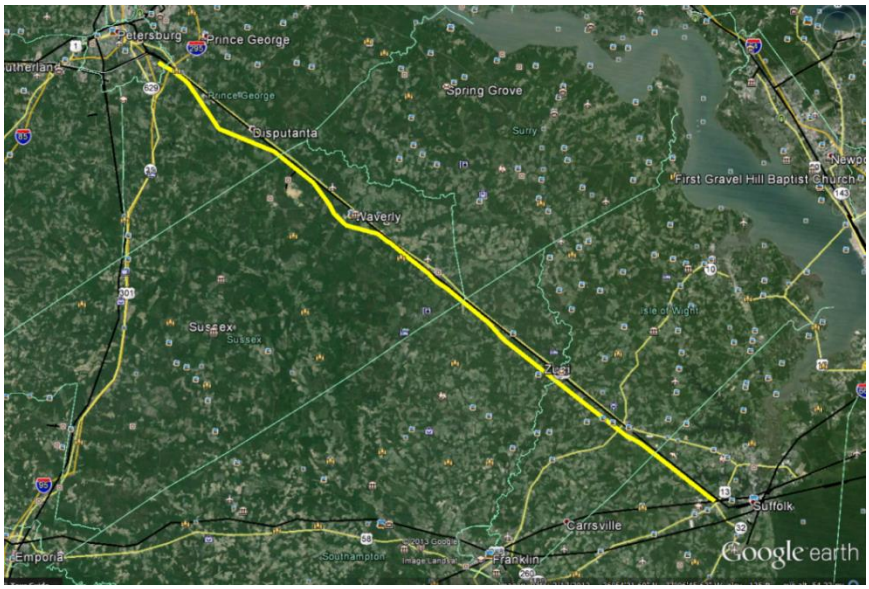
The Kilby to Proctors Bridge Road segment of the Northern Greenfield extends for 20.6 miles from just west of Kilby to the vicinity of Proctors Bridge Road, north of Ivor. Passing underneath the Norfolk Southern rail bridge at Kilby, the alignment turns northwesterly across open countryside to parallel the electric line and finally join and share its right-of-way. It follows a utility line right-of-way for about 10 miles, past Zuni, before crossing to the north side of the US 460 highway alignment.

As an alternative to using the Norfolk Southern rail corridor between Kilby and Zuni, as shown in Exhibit 3-18 an electric power line right-of-way was seen to extend on a mostly straight alignment all the way from Kilby to Disputanta.[21] Aside from the fact that it already exists and is mostly straight, this electric utility corridor bypasses the small towns (Windsor, Wakefield, etc.) along the way. Using the utility right-of-way instead of the Norfolk Southern rail corridor could provide a way to avoid the property takings that would otherwise be needed for widening the rail right-of-way through the towns.

[20] The initial concept was to develop one greenfield alignment completely south and one completely north of the existing US-460 corridor. For the Northern greenfield, an early concept was based on the idea of heading from Bowers Hill straight across the Dismal Swamp, following US-58 around the north side of Suffolk and then heading west to join I-295 at Hopewell. The main advantage of the Suffolk Bypass is that trains heading west from Bowers Hill could immediately accelerate to 220-mph. The alternative was developed to the point of preliminary discussions with Virginia DOT regarding its feasibility. However, some problems with this concept soon became apparent. Local trains that stop at a suburban Suffolk station along US-58 would not save any time, and a northern Suffolk Bypass was seen to require extensive elevated structure because of extensive wetlands and highway right-of-way restrictions. While the alternative was not considered fatally flawed, it was apparent that this segment would be very expensive to develop. Because two other options for following existing rail alignments through Suffolk could likely be developed at a much lower cost, it was considered that a northern Suffolk Bypass would likely be screened early in any prospective environmental evaluation. As a result a downtown Suffolk alternative to Kilby as previously described was developed instead.

[21] For the purposes of this study only the segment from Kilby to Zuni is included in the rail option. The extended use of this electric utility corridor all the way from Kilby to Disputantia could however, be developed as an additional option during the Tier I environmental study, if desired.

Exhibit 3-18: Electric Utility Right-of-Way Paralleling the Norfolk Southern Rail Corridor



Appendix F includes a feasibility study on transportation use of utility corridors, completed by the Maryland Department of Transportation in April 2002. While this study noted a number of concerns regarding the use of utility corridors, many of those (such as sharp turns and undulating topography) are site specific. On the other hand, the report provided a number of examples of examples where transportation facilities have been successfully developed within utility rights of way, including both highway and rail cases. One of the key recommendations of the report was the replacement of lattice towers with the newer pole designs, if necessary to reduce the physical footprint of the utility structures. This can free some land for accommodating the transportation facility within the right-of-way. In designing the corridor it is important to provide access for maintenance of both power transmission lines and the transportation facilities. Although there are challenges associated with use of utility rights of way, there are opportunities also, and many instances of successful projects built within such rights of way.

Beyond this however, an important benefit potentially associated with using utility right-of-way is that the environmental GIS shape files show that, in many cases, the right-of-way associated with the electric power line has already been compromised. As shown in Exhibit 3-19, the power line right-of-way can be seen to cut a swath through some existing wetlands just as railroads or highways do. As a result, there is an opportunity to reduce wetland impacts by co-locating a rail line inside the existing electric power corridor.

Exhibit 3-19: Electric Utility Right-of-Way Cuts through Wetlands

Although there are some engineering issues associated with adding a rail line to an electric utility right-of-way, such use is not unprecedented. It would also provide a clear benefit to electrification of the rail line, since the necessary power source would be directly overhead. Exhibit 3-20 shows an existing rail line co-located with two electric power lines along Hiawatha Boulevard in Minneapolis, MN. Closer to home, Exhibit 3-21 shows the CSX Phoebus branch in Hampton, VA which shares its right-of-way along Pembroke Avenue with a high voltage electric transmission line.

Exhibit 3-20: Rail Line Co-located with Electric Power Lines in Minneapolis, MN

Exhibit 3-21: Rail Line Co-located with Electric Power Lines in Hampton, VA

Exhibit 3-22: Elevation Profile, Northern Greenfield

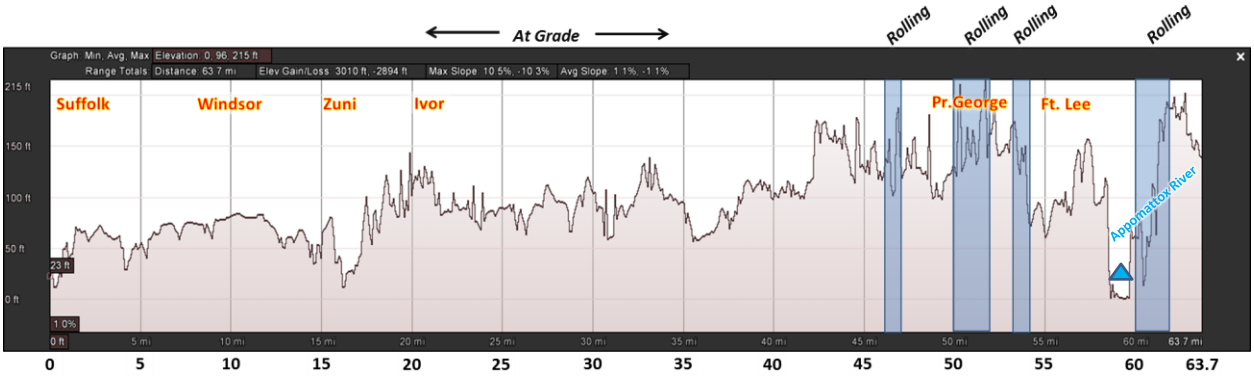


Exhibit 3-22 shows the elevation profile for the Northern Greenfield. (Please note that this profile extends from Suffolk all the way through Fort Lee to a possible connection with the East Shore Greenfield near Moore Lake.) From this exhibit, it can be seen that the first 20.6 miles west from Suffolk past Ivor are all across level terrain, but there are also significant wetland issues in this stretch. The cost from Kilby to Proctors Bridge Road is based on 20.6 miles of new double track; 2.4 miles of which are on bridge structure over wetlands and flood plains, and the balance of 18.2 miles at grade. The alignment has 32 roadway crossings. The estimated wetland taking is 12.96 acres, and assuming that utility power line towers can be avoided, 14 property takings are needed for a 100' right-of-way.

PROCTORS BRIDGE ROAD TO I-295 VA 646 OVERPASS

Beyond Ivor, the proposed Northern Greenfield alternative passes through open countryside north of US 460 but must curve gently to avoid wetlands and minimize impacts. Since it is a high speed alignment curves are limited to a maximum of 15-minutes rotation per 100 feet of distance, so it is not always possible to cross wetlands at right angles. Nonetheless, an effort has been made to avoid as many wetlands as possible. According to the Virginia Natural Landscape Assessment (VaNLA, see Appendix D Section 4), this segment traverses significant stretches of contiguous natural habitat, to avoid fragmentation the need for wildlife overpasses and underpasses along this stretch of track will have to be carefully addressed, in the next phase of environmental planning.

The cost from Proctors Bridge Road to the I-295 VA 646 Overpass is based on 33.4 miles of new double track; 0.4 miles of which are on bridge structure over wetlands and flood plains, 4 miles of which are in rolling terrain, and the balance of 29 miles are at grade. The alignment has 68 roadway crossings. The estimated wetland taking is 10.71 acres, and 32 property takings are needed for a 100' right-of-way. It also includes a $50 million placeholder (per discussion of Exhibit 3-14) for the transition into the I-295 median.

I-295 VA 646 OVERPASS TO OAKLAWN BOULEVARD

This critical 2.3 mile segment of I-295 passes through the Hopewell conurbation from the south to the north; based on consultation with Virginia DOT, it is assumed that the rail alignment will be able to utilize this section of I-295 median at grade. This section is costed as 2.3 miles of double track on new roadbed, since the I-295 median is already graded. A $20 million placeholder is also included here for the development of a high speed rail station at Hopewell.

Beyond Oaklawn Boulevard there is a possible option for heading across Fort Lee to connect with the East Shore Greenfield near Moore Lake. This section would have some rolling terrain issues and also an Appomattox River crossing. However, since Fort Lee is an active military training reservation, it is not clear that this connection would be allowed, and a tunnel option would not be cost effective. The I-295 median provides alternative to building this connection across Fort Lee, so it is assumed that the Northern Greenfield alternative will be paired with I-295 north to Richmond, rather than with the East Shore Greenfield.

OAKLAWN BOULEVARD TO RICHMOND AIRPORT

From Oaklawn Boulevard, the rail alignment will remain on I-295 to the Pocahontas Parkway interchange, a distance of 14.8 miles. From this interchange a greenfield connection would leave the I-295 median and fly over to the north side of the CSX Peninsula Subdivision rail line, a distance of 2.2 miles.

The I-295 section is costed as 13.8 miles of double track on new roadbed, since the I-295 median is already graded. To avoid double counting of costs, this backs out a mile for the length of the Appomattox and James River bridges, which are accounted for by placeholders: $50 million for a double tracked Appomattox River bridge, and $350 million for a new high level James River crossing parallel to the current Varina-Enon Bridge[22]. The alignment has 3 roadway crossings that need short bridges.

[22] The Øresund Bridge linking Denmark and Sweden carries a four lane highway and a double tracked railway, and like the Varina-Enon Bridge, it is also of Cable Stayed design. It is possible that by widening and strengthening the Varina-Enon Bridge a rail alignment could be added to it for less cost than building a parallel new high level rail bridge. See: http://en.wikipedia.org/wiki/%C3%98resund_Bridge

The greenfield section that connects over to the CSX rail line is estimated as 2.2 miles of new double track, 1.5 miles of which is graded on rolling terrain and 0.7 miles of bridge structure over wetlands and flood plains. The alignment has 3 roadway crossings and one rail line crossing that need short bridges. The estimated wetland taking is 5.98 acres, and 1 property taking is needed to obtain a 100' right-of-way for this connection. It also includes a $50 million placeholder for the transition out of the I-295 median.

RICHMOND AIRPORT TO THE FULTON GAS WORKS

From the Richmond Airport to the Fulton Gas Works, the proposed high speed alignment would parallel the CSX Peninsula Subdivision on the north side. At the Gas Works to gain access to Main Street station, the alignment would connect into the viaduct structure previously described.

One issue for this segment is where the proposed High Speed rail alignment passes 1,400 feet south of precision instrument runway 2/20 of Richmond International Airport. According to FAR Part 77 - Obstructions to Navigation[23] the required precision instrument approach slope is 50:1 with a buffer of 200 feet beyond the end of the runway. This means the highest vertical obstruction at 1,400 feet cannot rise more than 24 feet above the level of the runway. This should be enough vertical clearance to allow installation of electric catenary over the High Speed tracks.[24] A possible mitigation may be trenching to lower the High Speed tracks by a few feet if necessary to fit the electrification overhead. A more detailed engineering assessment will be needed during the Environmental study to confirm that electric catenary can be installed without any impact on aircraft operations.

This greenfield section is costed as 5.2 miles of new double track on, 4.7 miles of which is on level terrain and 0.5 miles of bridge structure over wetlands and flood plains. The alignment has 8 roadway crossings but no wetland taking. Only one property taking is needed to obtain a 100' right-of-way for this section. In conjunction with the Fulton Gas Works to Richmond Main Street segment described earlier, this completes the description of the Northern Greenfield section.

3.2.5 RICHMOND DIRECT (OPTION 3)

The final remaining segment is the Richmond Direct alternative, from the Northern Greenfield at Proctors Bridge Road north of Ivor to Richmond Airport, from where it shares a common entry into Richmond with the I-295 alternative. The Richmond Direct alignment bypasses Hopewell and Petersburg, instead heading directly to Richmond over the shortest practicable route.

PROCTORS BRIDGE ROAD TO RICHMOND AIRPORT

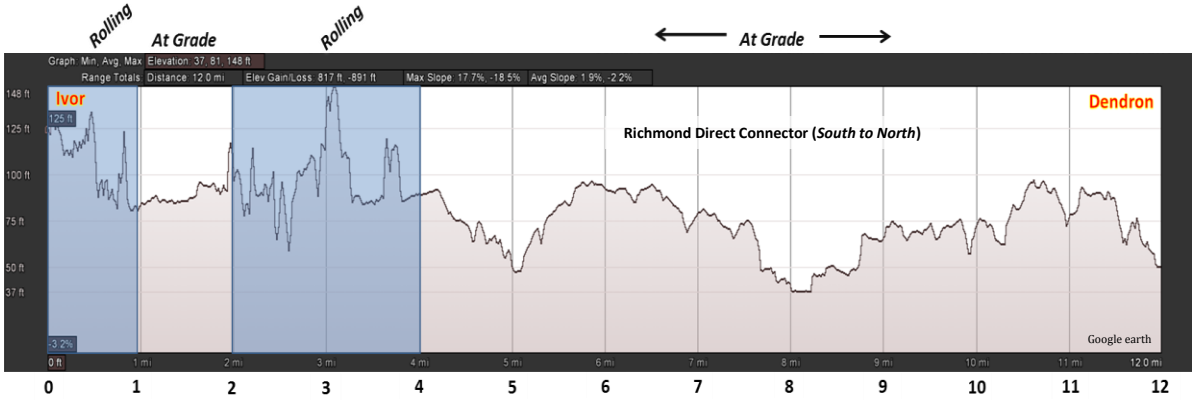
From Ivor, the Richmond Direct alternative heads directly towards Richmond, crossing the James River just south of Charles City at a point where the river is approximately ¾ mile wide. After this it bridges several wetland areas and crosses over the CSX Peninsula Subdivision, landing on the north side of the existing track. The alignment then follows CSX on the north side to Richmond Airport. Just like the other greenfields proposed in this study, a prospective Richmond Direct alignment was laid out on the principle of minimizing wetland impacts, while altogether avoiding protected parks and battlefields. Exhibit 3-23 shows the elevation profile for the original Richmond Direct option that includes the Suffolk Bypass. Exhibit 3-24 shows the elevation profile for the Ivor to Dendron (Proctors Bridge Road) connector that links the Northern Greenfield alignment with the Richmond Direct alignment. (East of Ivor the Northern and Richmond Direct Greenfields are the same.)

[23] See: http://www.wsdot.wa.gov/nr/rdonlyres/f2c1829f-7969-4a47-adcc-64c6b6320ba0/0/far_part77.pdf
[24] The European height for High Speed catenary is 18-19 feet above the rail. http://www.railpac.org/2010/01/26/high-speed-and-commuter-rail-electrification-is-catenary-height-an-issue/

Exhibit 3-23 shows the elevation profile for the Richmond Direct option if the bypass around the northern outskirts of Suffolk were used. With this option there are no terrain issues at all until the north side of the James River, where three miles of alignment are classified as rolling terrain. Exhibit 3-24 shows the elevation profile for the alignment section connecting the Northern Greenfield at Ivor to the Richmond Direct option at Dendron. This identifies three additional miles of rolling terrain to make the connection between the Northern Greenfield (east of Ivor) and the Richmond Direct alignment (west of Dendron.)

Exhibit 3-23: Elevation Profile, Richmond Direct Option from Suffolk to Richmond

Exhibit 3-24: Elevation Profile, Richmond Direct Connector from Ivor to Dendron



The cost from Proctors Bridge Road to Richmond Airport is based on 49.6 miles of new double track; 4.6 miles of which are on bridge structure over wetlands and flood plains, 0.7 miles on a high level bridge crossing the James River, 0.6 miles on a low level bridge across Upper Chippokes Creek, 6 miles are graded in rolling terrain, and the balance of 37.7 miles at grade. A placeholder cost of $350 million is assumed for the high level James River crossing and $50 million for the low level crossing of Upper Chippokes Creek. Most of the wetland issues occur north of the James River. According to the Virginia Natural Landscape Assessment (VaNLA, see Appendix D Section 4), this segment traverses significant stretches of contiguous natural habitat, to avoid fragmentation the need for wildlife overpasses and underpasses along this stretch of track will have to be carefully addressed. Some of these landscape fragmentation issues could also be addressed by minor alignment shifts in the next phase of environmental planning. The segment has 76 roadway crossings and 35.24 acres of wetland taking. 23 property takings are needed to obtain a 100' right-of-way.

Costs and statistics for the overall Options 1A, 1B, 2A, 2B and 3 have been developed on an overall route basis by adding the individual segment costs together. These summary results by route option will be reported in Chapter 5.

3.3 SEGMENT BY SEGMENT ANALYSIS – NEWPORT NEWS TO RICHMOND

The following subsections will address environmental and engineering conditions existing along each route segment from Newport News to Richmond. As described in Chapter 2, a number of possible route options have been identified for Peninsula rail service, but only one option has been developed here for costing purposes. The other options are suggested for scoping a proposed Tier I environmental study and may be more fully assessed during the course of that study. As can be seen in Exhibit 3-2, the Peninsula representative route includes three segments:

1. Richmond Direct Segment 1: Richmond to Roxbury
2. Toano Connector Segment 2: Roxbury to Toano
3. Shared CSX Peninsula Segment 3: Toano to Newport News

However, segment #1 has already been developed as part of the Richmond Direct alignment to Norfolk and Peninsula diesel trains could use this track (130-mph on diesel power, not using the overhead electrification) for no additional capital cost. Only segments #2 and #3 will be developed here.

3.3.1 NEWPORT NEWS TO TOANO - EXISTING RAIL SEGMENT #3

The segment from Newport News to Toano would follow the existing CSX rail line and be limited to a 90-mph top speed. This segment starts at downtown Newport News and continues 35 miles along the CSX corridor to Toano. It has three stations: a proposed new station at downtown Newport News, a new station currently under development at Bland Boulevard, and the existing Amtrak station at Williamsburg. The analysis assumes that the existing Amtrak station at Mercury Boulevard will already have been closed and replaced by the Bland Boulevard multi-modal station.

Because of the very early stage of current project development, some very preliminary assumptions have been made regarding costs for this segment. Pending completion of a capacity analysis, this study assumes that full double track should be the *starting point* for any discussion with CSX of capacity needs. The cost estimate for this segment assumes that the full length of the corridor (all 35 miles from downtown Newport News to Toano) will receive one added track on new roadbed. The existing corridor already includes some double track sections so this would in fact be sufficient to add some sections of third track to the Peninsula corridor. Although the existing track is in good shape and supports passenger service today, an allowance of $1 million per mile has been provided for upgrading the existing CSX track as well. Finally an allowance of $3.1 million per mile has been included for full bi-directional signaling, Positive Train Control and crossovers all the way from downtown Newport News to Toano.

The plan assumes the use of push-pull or double ended trains that have a diesel power car at both ends. These trains won't need turning so there is no need for wye track. The project also assumes that a train turnaround maintenance base will be located near the end-of-line station in downtown Newport News.

This results in a budget of $253 million to restore double track on the existing (already graded) track bed and bridges for track along this 35 mile segment, and for signal improvements. In addition, there are 57 grade crossings, an average of 1.6 crossings per mile. A cost of $1.03 million per crossing is proposed to fully quad-gate and seal the corridor. This goes beyond the requirement for 90-mph operations where only conventional gates and flashers are legally required. However the additional expenditure will enhance safety and may also allow for introduction of some "quiet zones" for mitigating noise impacts.

Overall the cost estimate for the Newport News to Toano segment is $311 million or $8.9 million per mile.

This estimate is subject to a number of uncertainties, in regard to both the geographical and operational scope of the project:

- A decision must be made whether to extend the service all the way to a downtown Newport News station. The distance from Bland Boulevard to the proposed downtown station is approximately 11 miles, and part of this distance includes the CSX Newport News terminal complex. For this study, the downtown Newport News station has been retained; based on the assumed average cost of $8.9 million per mile, this would give a budget of nearly $100 million for extending rail service downtown. *This $100 million is included in the current cost estimate for the Peninsula rail service as well as in the Cost Benefit justification*. While a Bland Boulevard station may adequately serve Newport News, a downtown station would better serve Hampton. The value of a downtown station or even a possible further service extension along the Phoebus Branch needs more study in a future assessment.
- HRTPO has proposed a new commuter rail service from Toano to downtown Newport News.[25] The time frame and priority of possible implementation of this service remains unclear; however, there could be an opportunity to advance the commuter project jointly with development of intercity passenger rail. Adding a commuter rail component will likely require some additional rail infrastructure, however the core capacity improvements could be shared by the two passenger rail systems as well as by freight trains. In general it has been found that where commuter rail systems are developed parallel to intercity systems, as is also occurring in northern Virginia from Fredericksburg into Washington D.C., rather than cannibalizing ridership it actually tends to boost the ridership of *both* systems -- so there could be synergies from advancing the two projects together. A decision needs to be made whether to advance Enhanced Intercity passenger rail on the Peninsula by itself or to add an optional commuter rail element into the scope of the Tier I EIS alternatives analysis. While the two projects must be kept separate and distinct, some significant economies could be achieved by coordinating the planning of the two projects. However, the current capital cost estimate provides only for the intercity rail operation, and does not include any incremental costs that might be needed for adding a commuter rail service.
- Finally, all costing assumptions, particularly in regard to the adequacy of the proposed double track for mitigating freight capacity needs, are pending the outcome of a detailed line capacity analysis[26] as well as formal CSX involvement. A "screening" level capacity assessment[27] can provide a rigorous methodology for estimating preliminary capacity needs in a Tier I EIS, while detailed simulation using the Rail Traffic Controller (RTC) tool is normally done to finalize the analysis[28] during a Tier II EIS. This proposal for adding passenger service to the Peninsula is still

[25] See the *James City County/Williamsburg/York County Comprehensive Transportation Study*, March 2012: pages 15, 45, 46 and 47 at http://www.yorkcounty.gov/Portals/3/JCC%20WMB%20YC%20Final%20Report_reduced.pdf and also pages ES-14, ES-20 of http://www.drpt.virginia.gov/activities/files/Final_Report_03-17-11.pdf

[26] A particular challenge will be find a cost effective way for passenger trains to reach a downtown Newport News station. One issue is that coal trains are apparently being stored on the main line if they are not wanted right away at the coal terminal. For storing trains as needed, it might make sense to propose upgrading the Receiving Yard at Newport News as an alternative to adding a mainline track downtown. Given the $100 million that is included in the capital cost estimate for extending rail service downtown, it seems likely that this funding could support a substantial reconfiguration of the existing rail yard as needed. Doing this may allow the passenger rail service to use the existing main track on the south side of the rail corridor to reach a downtown station. This needs more discussion with CSX so if HRTPO decides to include it in the project scope for the next phase of work, a full resolution might require the use of detailed yard modeling tools like TEMS' Switch-It model in addition to normal over-the-road line capacity modeling.

[27] See: http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2918 and http://www.dot.state.mn.us/planning/railplan/docs/mwrri/6_Freight_Capacity_Methodology_and_Results.pdf

[28] The high level of infrastructure detail required by the RTC model, in particular precise locations of signals, switches, etc. may not be fully known or decided at the time of a first-cut capacity needs assessment. This level of infrastructure detail requires that Engineering design be completed to at least a Preliminary Engineering level. Earlier than this, the use of other capacity planning tools may be more cost effective.

un-negotiated and un-funded. The preliminary findings of this report are not to be construed as any commitment on the part of CSX to operate additional service or upgrade infrastructure.

3.3.2 TOANO TO ROXBURY – GREENFIELD CONNECTOR SEGMENT #2

This segment would be a 23.6 mile greenfield connector from Toano to Roxbury. It is assumed that this new dedicated double track will be fully grade separated and built to 220-mph geometric standards, but not electrified. Thus, high performance diesel trains could run up to 130-mph over it. Optionally if dual-mode diesel/electric trains were deployed, the segment could be electrified and operated at up to 220-mph (depending on the specific speed capabilities of the dual-mode trains) for additional time savings.

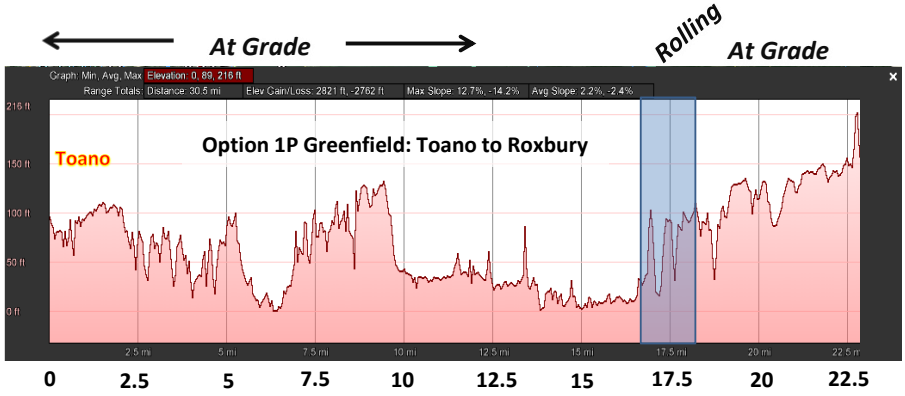
For the most part the proposed rail alignment follows an electric utility right-of-way -- although in a few places, particularly where the electric line changes direction, it is necessary to deviate from the utility right-of-way in order to ease the curves. Maximizing the use of the utility right-of-way minimizes the need for property takes, although 19 takes are still necessary because of these curve transitions.

The central portion of the power line corridor crosses the Chickahominy River. Although the river is not navigable this far north, in this area the utility right-of-way will likely require bridging to avoid wetland impacts. An allowance of 3.6 miles of low double track bridge structure is included in the overall 23.6 mile length. Because of this aggressive use of bridge structure, only 2.7 acres of lower value wetland are proposed to be filled and remediated.

While 3.6 miles are on bridge, the remaining of 20.0 miles of double track has been conservatively costed based on average 15' fill height, although as shown in Exhibit 3-25, much it could actually be at grade. All 23.6 miles have signals, Positive Train Control and interlockings and crossovers every 10 miles.

This segment also includes 22 rail and highway crossings that must be grade-separated, and average of 0.9 crossings per mile. A rural land value of $137,000 per mile has been assumed in this area plus the cost of property takes at $161,000 each. This leads to an overall cost for this segment of $609 million, an average of $25.8 million per mile for double track, *non-electrified* infrastructure.

Exhibit 3-25: Elevation Profile, Peninsula Connector from Toano to Roxbury



4. ENGINEERING ANALYSIS

Building on the route development that has been described in Chapters 2 and 3, this chapter presents the unit capital costs to be used to develop study costs for the Hampton Roads-Richmond; and develops the Capital Cost estimate for all the options, based on detailed information presented in Chapters 2 and 3, and elsewhere in the report. The Chapter concludes by presenting a benchmarking analysis comparing the study results with those from comparable corridors elsewhere.

4.1 INTRODUCTION

A capital costing methodology was developed to identify infrastructure rolling stock (equipment) costs and land costs. Land costs are presented separately, as a placeholder for access to railroad rights-of-way and for procurement of additional privately owned property where required to construct new passenger rail infrastructure.

The Engineering Assessment for the Vision Plan is being conducted at a feasibility level of detail and accuracy. Exhibit 4-1 highlights the levels of accuracy associated with typical phases of project development and engineering design. A 30% level of accuracy is associated with the evaluation of project feasibility; while the level of accuracy of 10% is achieved during final design and production of construction documents. This phase of the study is only the first step in the project development process. As shown in Exhibit 4-1, the cost estimate is intended to be a mid-range projection with equal probability of the actual cost moving up or down.

Exhibit 4-1: Engineering Project Development Phases and Levels of Accuracy Development

Development Phases	Approximate Engineering Design Level*	Approximate Level of Accuracy**
Feasibility Study	0%	+/- 30% or worse
Project Definition/Advanced Planning	1-2%	+/- 25%
Conceptual Engineering	10%	+/- 20%
Preliminary Engineering	30%	+/- 15%
Pre-Final Engineering	65%	+/- 15%
Final Design/Construction Documents	100%	+/- 10% or better

The first step in the Engineering Assessment is to divide each corridor into segments. Route segments for existing railroad rights-of-way generally begin and end at major railroad control points or rail stations. For greenfield alignments, segments begin and end at stations or junction points. Typical corridors are divided into three to five route segments. These segments are discussed and defined in Chapter 3. A systematic engineering planning process has been used to conduct the Engineering Assessment using the five basic costing elements:

- Guideway and Track Elements
- Structures – Approaches, Flyovers, Bridges and Tunnels
- Systems
- Crossings
- Stations and Maintenance Facilities

Three auxiliary costing elements have been defined in the chapter as follow:

- Right-of-Way and Land
- Vehicles
- Professional Services & Contingencies

The Engineering Assessment will be based on these eight costing elements. In addition to the field inspections and extensive work with GIS and railroad track charts, the assessment will include a thorough review of the alignment studies and estimate the costs.

4.2 INFRASTRUCTURE CAPITAL COSTS DEVELOPMENT

The infrastructure capital costs are summarized in this section of the chapter were similar to that presented in Preliminary Vision Plan and have been updated to 2013 dollars. The unit cost data base and corridor infrastructure costs are appropriate for a Vision Plan Feasibility Study. The costs will be further refined in future phases of work when the Alternatives Analysis for the Tier 1 and Tier 2 EIS work is undertaken.

The infrastructure capital unit costs used in the development of the preliminary capital cost estimates were developed from TEMS library of HSR unit costs. Peer panels, freight railroads and construction contractors have reviewed these costs. In addition, a summary validation was completed comparing the TEMS unit costs with unit costs used in regional rail studies around Virginia. Capital cost categories include:

- Land and right-of-way
- Sub-grade, structures and guideway
- Track
- Signals and communications
- Electrification
- Demolition
- Stations
- Maintenance and facilities
- Highway and railroad crossings
- Fencing and corridor protection

In addition to the engineering assessment, the capital costing methodology identifies rolling stock (equipment) costs and land costs. Land costs are presented separately, as a placeholder for access to railroad rights-of-way and for procurement of additional privately owned property where required to construct new passenger rail infrastructure.

Using the Engineering News Record Construction Cost Index (ENR CCI) Indices, unit costs used in this preliminary/initial portion of the Vision Plan study were adjusted for geographic region and annual escalation. Unit Prices will be adjusted to Regional Conditions and Escalate from 2009 to 2013. The following adjustment will be made:

- Unit Prices were based on the recent Rocky Mountain Rail Authority Business Plan for Denver region which was developed in 2009 dollars.
- From ENR CCI Analysis, the Denver to Hampton Roads adjustment is 97 percent, as the benchmark prices are slightly higher in the Denver area than they are in Hampton Roads.
- According to ENR CCI, National Cost Indices cost increases from 2009 to January 2013 is the ratio of ENR CCI for 2013 divided by that of 2009[1] which is 1.085.

With the Regional Adjustment Factor of 0.97, and inflation of 1.085, the Escalation Factor from the Denver regional study of 2009 to Hampton Roads January 2013 costs is the product of 0.97 * 1.085, which is 1.05.

The unit costs in the following section were estimated by applying this adjustment factor to the previous developed representative unit costs in previous TEMS work for the Midwest Regional Rail Authority high-speed rail studies and for the Rocky Mountain Rail Authority High-Speed Rail studies (as discussed earlier in Preliminary Vision Plan report).

4.3 RAIL CAPITAL UNIT COSTS

The base set of unit costs addresses typical passenger rail infrastructure construction elements including: roadbed and trackwork, systems, facilities, structures, and grade crossings. In the tables below, only a subset of the costs were actually used in Capital Cost development. Those costs are highlighted in yellow.

4.3.1 TRACKWORK AND LAND ACQUISITION

The FRA requires that passenger trains operating on the general railroad system comply with stringent crashworthiness standards. For the purposes of defining requirements necessary to proceed with the study and in order to develop planning level capital costs, it has been assumed that highway traffic and adjacent high speed trains will be separated by concrete barriers. On tangent highway and track segments, there exists a small probability that automotive vehicles will leave the highway. Thus, protection against highway traffic incursions into the high speed rail median would be provided using NCHRP Report 350 Level 5 highway concrete barrier walls. In curved median segments, where accidents are more likely, we have planned for NCHRP Level 6 barriers. It is anticipated that high speed rail systems will be separated from the freight rail corridors by at least 25 feet between track centers where practicable. Chain link fencing will be provided throughout the system in all corridors to prevent the intrusion of trespassers and animals. These planning assumptions may be subject to modification as a result of federal or state rule making.

Land acquisition costs for right-of-way owned and controlled by the railroad industry is always an issue when attempting to introduce new passenger rail service. Since its inception, Amtrak has had the statutory right to operate passenger trains over freight railroad tracks and rights-of-way. When using freight tracks, Amtrak is required to pay only avoidable costs for track maintenance along with some out-of-pocket costs for dispatching.[2]

[1] http://www.cahighspeedrail.ca.gov/assets/0/152/302/314/288d8ea6-bf10-4e14-80fc-fc92bd4ba48a.pdf and methodology based on Unit Price Regional & Escalation Analysis Rocky Mountain Rail Authority (RMRA), High Speed Rail Feasibility Study http://rockymountainrail.org/documents/RMRA_HSRBP_Appendix_F_03.2010.pdf

[2] However, these payments do not cover all of the freight railroads' incremental costs associated with dispatching Amtrak's passenger trains. Railroad costs increase due to delays caused by Amtrak's tightly scheduled trains. Track capacity constraints and bottlenecks create unreliable conditions where train delays often become unavoidable. While federal regulations give passenger trains dispatch priority, railroad dispatchers often encounter congestion where it becomes difficult to control traffic and adhere to Amtrak's timetables. In some cases, Amtrak will offer the railroads a payment to provide on-time passenger train performance. On heavily used line segments, however, these incentive payments only partially compensate a railroad for the costs of increased delay, and some railroads simply refuse to accept incentive payments. On lightly used lines, the economic rationale for making these payments is questionable since passenger trains cause very little delay on such tracks.

Amtrak's payments do not include any access fee for the use of a railroad's tracks or its rights-of-way. Amtrak's federal statutory right-of-access has never required such a payment, and therefore, Amtrak avoids paying a fee or "rent" for occupying space on privately held land and facilities.

However, this study assumes a cost for access based on estimated across-the-fence land values would be included as part of the up-front capital expense, and would be used to purchase the rights to use the underlying railroad rights-of-way for the passenger service. It is assumed that railroads would receive this compensation in cases where the construction of a dedicated high speed passenger track is on their property. If new track cannot be constructed within the existing railroad rights-of-way, then this cost would fund the possible acquisition of adjacent property.

Elsewhere land will need to be purchased directly from land owners. Where highway rights-of-way are proposed, the study assumes that right-of-way or air rights access would be granted by appropriate authority at no cost to the rail system.

The outright purchase of land is not the only method whereby railroads could receive compensation for access to railroad rights-of-way. Commuter rail development provides examples of various types of payments for access rights. Some of these projects involved the purchase of the railroad rights-of-way while others provide up-front capital improvements in return for access to a railroad's tracks. The actual methods of payment remain to be determined during negotiation, and may depend on the importance of the track to the freight railroad as well as the level of capital to be invested by the passenger rail authority.

One area of possible concern is the freight railroads' ability to retain operating control over their rights-of-way. Whenever transit systems have paid full price to acquire a freight rail line, as on some commuter rail projects, the transit agencies have assumed operating control over the property. However, this study has assumed that the freight railroads would retain dispatching control over these rights-of-way. The railroads would have the right to use the increased capacity provided by the passenger system for its high speed freight services.

A 100-foot right-of-way will be assumed for the greenfield, except where the alignment falls within an existing publicly-owned right-of-way, such as a highway or street alignment, no cost to the project for that particular right-of-way has been assumed. Where the geometric requirements take the alignment outside of the public right-of-way, impacted parcels will be evaluated and a square foot quantity calculated. A unit cost per acre was developed in conjunction with other studies. Exhibit 4-14 shows the unit costs used for trackwork and land acquisition.

Exhibit 4-2: Unit Capital Costs, Trackwork in $2013.

Item No.	Description	Unit	Unit Cost (Thousands of $2013)
1.1	HSR on Existing Roadbed (Single Track)	per mile	$1,246.11
1.2	HSR on Existing Roadbed (Double Track)	per mile	$2,492.42
1.3	HSR on New Roadbed & New Embankment (Single Track)	per mile	$1,872.29
1.31	HSR Single Track 15' offset added to existing corridor on 15' fill	per mile	$2,532.29
1.4	HSR on New Roadbed & New Embankment (Double Track)	per mile	$3,355.65
1.41	Greenfield Double Track at Grade	per mile	$3,355.65

1.42	Greenfield Double Track Rolling Terrain	per mile	$3,713.65
1.43	Greenfield Double Track Mountainous Terrain	per mile	$4,785.65
1.44	HSR Double Track 15' offset added on 15' fill	per mile	$4,807.82
1.45	HSR Double Track 30' offset added on 15' fill	per mile	$5,599.85
1.46	HSR Double Track 30' offset added on 15' Retained Earth fill	per mile	$17,724.11
1.5	HSR New Double Track on 15' Retained Earth Fill	per mile	$17,724.11
1.6	Timber & Surface w/ 33% Tie replacement	per mile	$278.62
1.7	Timber & Surface w/ 66% Tie Replacement	per mile	$415.33
1.8	Relay Track w/ 136# CWR	per mile	$444.29
1.9	Freight Siding	per mile	$1,144.50
1.10	Passenger Siding	per mile	$1,726.77
1.11	NCHRP Class 6 Barrier (on curves)	lineal ft.	$1.38
1.12	NCHRP Class 5 Barrier (on tangent)	lineal ft.	$0.21
1.13	Fencing, 4 ft. Woven Wire (both sides)	per mile	$63.95
1.14	Fencing, 6 ft. Chain Link (both sides)	per mile	$191.97
1.15	Fencing, 10 ft. Chain Link (both sides)	per mile	$219.65
1.15a	Sound Wall Fencing	per mile	$1,350.00
1.16	Decorative Fencing (both sides)	per mile	$494.45
1.17	Drainage Improvements (cross country)	per mile	$82.83
1.18	Drainage Improvements in Median or along highway	per mile	$662.56
1.19	Land Acquisition Urban and Resort (100' of ROW)	per mile	$410.35
1.20	Land Acquisition Rural (100' of ROW)	per mile	$136.82
1.21a	Land Acquisition Rural US-460 Corridor	per acre	$35.00
1.21b	Property Takes (overall average per take)	each	$161.00
1.21c	Wetland Mitigation	per acre	$150.00
1.21	#33 High-Speed Turnout	each	$712.73
1.22	#24 High-Speed Turnout	each	$564.67
1.23	#20 Turnout Timber	each	$155.59
1.24	#10 Turnout Timber	each	$86.55
1.25	#20 Turnout Concrete	each	$312.45
1.26	#10 Turnout Concrete	each	$148.06
1.27	#33 Crossover	each	$1,425.56
1.28	#20 Crossover	each	$625.76
1.28a	Interlockings and Crossovers every 10 miles	Per mile	$265.00
1.29	Elevate & Surface Curves	per mile	$72.76
1.30	Curvature Reduction	per mile	$493.18
1.31	Elastic Fasteners	per mile	$102.88

4.3.2 STRUCTURES: APPROACHES, FLYOVERS, BRIDGES, AND TUNNELS

A complete inventory of bridges has been developed for each existing rail route from existing track charts. For estimating the cost of new bridges on either green field alignments or along existing rail beds, conceptual engineering plans will be used for a bridge to carry either single or double tracks over

highways, streams, valleys, and rivers. Some bridges require rehabilitation on the abutments and superstructure. This type of work includes pointing of stone abutment walls, painting of bridges, and replacement of bearings. Many of the major bridge cost estimates will be estimated only as placeholders, which will be subject to more detailed engineering analysis in the future. Tunneling costs lie within the $20-73 thousand per linear foot range, where the higher cost was from the long undersea English Channel tunnel; but the estimates in Exhibit 4-3 were considered as benchmarks for the probable cost of tunnels and these costs will be used in this study.

Exhibit 4-3: Unit Capital Costs, Structures in $2013

Item No.	Description (Bridges-under)	Unit	Unit Cost (Thousands of $2013)
2.1	Four Lane Urban Expressway (Rail over Highway)	each	$6,067.52
2.2	Four Lane Rural Expressway (Rail over Highway)	each	$5,051.03
2.3	Two Lane Highway (Rail over Highway)	each	$3,832.50
2.4	Rail (New Rail over Existing Rail)	each	$3,832.50
2.5	Minor river	each	$1,016.48
2.6	Major River	each	$10,162.30
2.7	Double Track High (50') Level Bridge	per LF	$15.27
2.8	Rehab for 110	per LF	$17.61
2.9	Convert open deck bridge to ballast deck (single track)	per LF	$5.83
2.10	Convert open deck bridge to ballast deck (double track)	per LF	$11.77
2.11	Single Track on Flyover/Elevated Structure	per LF	$5.30
2.12	Single Track on Approach Embankment w/ Retaining Wall	per LF	$3.71
2.13	Double Track on Flyover/Elevated Structure	per LF	$8.48
2.13a	Greenfield Double Track on Low Bridge	per LF	$8.90
2.14	Double Track on Approach Embankment w/ Retaining Wall	per LF	$6.89
2.15	Ballasted Concrete Deck Replacement Bridge	per LF	$2.65
2.16	Land Bridges	per LF	$3.29
2.17	Four Lane Urban Expressway (Highway over Rail)	each	$3,675.64
2.18	Four Lane Rural Expressway (Highway over Rail)	each	$2,619.06
2.19	Two Lane Highway (Highway over Rail)	each	$2,388.06
2.20	Rail (Existing Rail over New Rail)	each	$7,667.55
2.21	Two Bore Long Tunnel	route ft.	$46.67
2.22	Single Bore Short Tunnel	lineal ft.	$26.52

4.3.3 SYSTEMS

The capital cost estimates for this study include costs to upgrade the train control and signal systems. Unit costs for system elements are shown in Exhibit 4-4. Under the 110 mph or higher speed scenarios, the signal improvements include the added costs for a vital Positive Train Control (PTC) signal system. The FRA "Cab signal rule" requires that wayside signals be displayed within the engine cab for any speeds of 80 mph or high. The PTC system would do this. However it should be noted that NS policy prohibits exceeding 79 mph on its tracks. For this study PTC would only need to be applied only to new dedicated tracks and not the existing NS freight tracks.

Most US railroads that allow or provide passenger and freight service operate under manual control with wayside signals. Centralized traffic control (CTC) signaling is provided on busy corridors including Amtrak's Northeast Corridor. FRA requires that passenger service exceeding 79 mph operate with cab signaling/automatic train protection or automatic train stop to provide protection against operator errors. In addition, FRA is currently sponsoring demonstration projects to develop a universal communications based train control system, known as positive train control or PTC. New high speed passenger service will include sophisticated signal systems to comply with FRA mandates and provide safe, reliable operations. Such signal systems include train borne components and wayside equipment such as track circuits, switch operators, and wayside detectors for protection against intrusion, high water, hot bearings and dragging equipment.

Modern signal systems rely on digital communication systems for data transmission using radio, fiber optic cables or a combination or the two. In addition, the communication system provides radio for operations, supervisory control and data acquisition for power systems, passenger station public address, etc. Wayside space must be provided for ducts and enclosures to house signal and communication components.

Electrified high speed rail options require traction power substations and distribution facilities. Electric utility is expected to provide substations, transmission equipment and connections to the utility network with such costs covered in the utilization charges. As such, it is assumed that the electric utility would amortize the costs for bringing power to the substations, so the costs of modifications to the utility's grid are not included in the electrification cost estimate. Typical requirements for electrification include substations at 25 mile intervals and distribution conductors. In the case of electrified rail systems, overhead catenary conductors provide power to the train pantograph and the rails serve as return conductors. The catenary conductors are supported by poles and cross arms spaced at roughly 100-150 foot intervals. The catenary system contact wire is generally located 17 to 23 feet above the top of the rail. Additional electrical clearance or high voltage insulation is required to overhead bridge structures.

Exhibit 4-4: Unit Capital Costs, Systems, in $2013

Item No.	Description	Unit	Unit Cost (Thousands of $2013)
3.1	Signals for Siding w/ High-Speed Turnout	each	$1,591.23
3.2	Install CTC System (Single Track)	per mile	$229.62
3.3	Install CTC System (Double Track)	per mile	$376.52
3.4	Install PTC System	per mile	$181.36
3.5	Electric Lock for Industry Turnout	each	$129.29
3.6	Signals for Crossover	each	$878.39
3.7	Signals for Turnout	each	$501.98
3.8	Signals, PTC, Communications & Dispatch (Double Track)	per mile	$1,602.00
3.9	Electrification and Power Supply (Double Track)	per mile	$5,482.00

4.3.4 CROSSINGS

The treatment of grade crossings to accommodate 110-mph operations on existing rail is a major challenge to planning a high speed rail system. Highway/railroad crossing safety plays a critical role in future project development phases. A variety of devices were considered to improve safety including roadway geometric improvements, median barriers, barrier gates, traffic channelization devices, wayside

horns, fencing and the potential closure of crossings. Greenfield routes were developed with grade separations at street and roadway crossings. Exhibit 4-5 details the unit costs for highway and railroad grade crossings.

Exhibit 4-5: Unit Capital Costs, Crossings, in $2013

Item No.	Description	Unit	Unit Cost (Thousands of $2013)
4.1	Private Closure	each	$104.15
4.2	Four Quadrant Gates w/ Trapped Vehicle Detector	each	$617.38
4.3	Four Quadrant Gates	each	$361.45
4.4	Convert Dual Gates to Quad Gates	each	$188.26
4.5	Conventional Gates single mainline track	each	$208.30
4.6	Conventional Gates double mainline track	each	$257.30
4.7	Convert Flashers Only to Dual Gate	each	$62.79
4.8	Single Gate with Median Barrier	each	$225.91
4.9	Convert Single Gate to Extended Arm	each	$18.77
4.10	Precast Panels without Roadway Improvements	each	$100.44
4.11	Precast Panels with Roadway Improvements	each	$188.26

4.3.5 STATION/MAINTENANCE FACILITIES

Passenger stations and parking facilities include platforms, escalators/elevators and other circulation elements, passenger ticketing and waiting facilities, lighting security, and station administration facilities.

The terminal stations may require four tracks for passenger boarding, train layover and light maintenance.

A maintenance facility with sufficient capacity to service the fleet is required. The facility must provide space and equipment to service the rolling stock and maintain the track structure and systems. Storage tracks can be expanded as the fleet grows. Sophisticated component repair may be subbed out to contract shops. It is anticipated that the maintenance facility for a non-electrified system will be less sophisticated than that of an electrified rail system. Exhibit 4-6 shows the unit costs for types of stations, terminals, and maintenance facilities.

Exhibit 4-6: Unit Capital Costs, Railroad Station/Maintenance Facilities, in $2013

Item No.	Description	Unit	Unit Cost (Thousands of $2013)
5.1	Full Service - New - Low Volume - 500 Surface Park	each	$5,303.03
5.2	Full Service - Renovated - Low Volume- 500 Surface Park	each	$4,242.42
5.3	Terminal - New - Low Volume - 500 Surface Park	each	$7,954.55
5.4	Terminal - Renovated - Low Volume - 500 Surface Park	each	$6,363.64
5.5	Full Service - New- High Volume - Dual Platform - 1000 Surface Park	each	$10,606.06
5.5a	High-Speed Rail Station	each	$12,019.23
5.6	Terminal - New- High Volume - Dual Platform - 1000 Surface Park	each	$15,909.09
5.7	Heavy Maintenance Facility (non-electrified track)	each	$84,848.48
5.8	Heavy Maintenance Facility (electrified track)	each	$106,060.61
5.9	Layover Facility	lump sum	$10,606.06

4.3.6 OTHER COSTS

Please note that contingency and professional service allowances are added for infrastructure capital costs only. They are not added for land acquisition, property taking, wetland remediation or placeholder costs since these factors are the results of benchmarking rather than engineering cost comparisons.

CONTINGENCY

Contingency costs will be added as an overall percentage of the total construction cost. Contingencies are an allowance added to the estimate of costs to account for items and conditions that cannot be realistically anticipated. The contingency is expected to be needed as the project develops. The contingency is estimated at 30 percent of the construction cost elements. This contingency included 15%+ for design contingency and 15%+ for construction contingency.

PROFESSIONAL SERVICES AND ENVIRONMENTAL

The project elements included in the Professional Services category are design engineering, program management, construction management and inspection, engineering during construction, and integrated testing and commissioning. For a project of this size, an overall program manager with several section designers is needed to provide conceptual engineering, preliminary engineering, environmental studies, geotechnical engineering, final engineering and engineering during construction. Field and construction management services and integrated testing services and commissioning of various project elements also are required. Professional services and other soft costs required to develop in this study have been estimated as a percentage of the estimated construction cost and are included in the overall cost estimates as a separate line item. Overall this category adds 28% on top of the base cost and contingency. These costs include, as a percentage of construction cost:

- Design engineering and related studies 10%
- Insurance and Bonding 2%
- Program Management 4%
- Construction management and inspection 6%

- Engineering services during construction 2%
- Integrated Testing and Commissioning 2%
- Erosion Control and Water Quality Mgmt 2%

PLACEHOLDERS

The capital costs include allocation for special elements (placeholders) as conservative estimates for large and/or complex engineering projects that have not been estimated on the basis of unit costs and quantities. Placeholders provide lump sum budget approximations based on expert opinion rather than on an engineering estimate and are shown in the unit costs as lump sum items. Placeholders are used where detailed engineering requirements are not fully known. These costs will require special attention during the project development phase.

4.4 CAPITAL COST SUMMARY

The capital cost for developing a high speed 220-mph rail link between Norfolk, VA and Washington, DC with a 130-mph connecting link to Toano and Newport News has been estimated. The estimate shown in Exhibit 4-7 consists of several components:

1. Equipment cost was estimated as $590 million, for 14 high speed (220-mph) electric trains at $42.14 million each. This equipment cost is consistent with what was assumed for the cost of high speed trains in the Atlanta-Charlotte Tier I EIS Study. In Option 4, an additional $264 million is added for 7 high speed (130-mph) diesel trains at $37.71 million each.
2. The cost for the Richmond to Washington DC segment is updated to $4.06 Billion, based on a highly conceptual greenfield between those points. This cost was drawn from the earlier 2010 Hampton Roads Progress Report C (Exhibit C-3 on page C-40) and was increased 5% for inflation. It should be noted that the original Progress Report C cost of $2.129 billion assumed a 35% cost sharing with SEHSR. For this update however, it has been assumed that the Hampton Roads corridor would not share any of the cost with SEHSR or Amtrak, but rather to be conservative the Financial and Economic assessment assigns 100% of the cost of developing the greenfield to the HRTPO project. As a result the cost used was $2.129 / 0.65 * 1.05 = $3.439 billion for the Richmond to Washington D.C. segment. The increase of $600 million is fully explained by the additional cost for developing a 4-track access into Washington D.C. including the Long Bridge improvement, which has now been fully included in the updated cost for the Richmond to Washington DC segment. As a result, the Hampton Roads corridor improvement could afford to fully fund the cost of Washington D.C. rail access as part of its proposed development of a new greenfield alignment, since a positive Cost Benefit ratio was developed for the overall High Speed rail project fully including all these costs.
3. In Options 1-3, the cost for Newport News to Richmond was zero, reflecting the Step 2 3 trains per day at 90-mph scenarios that were evaluated in the DRPT EIS. Those scenarios assumed that the Peninsula service would not be upgraded beyond the currently planned level of 3 Round Trips according to the DRPT DEIS. However, for Option 4 a cost of $920 million has been assumed for developing a High Speed connecting greenfield to Toano and for upgrading the CSX track to Newport News, as described in Chapter 3.
4. The cost for Norfolk to Richmond was based on a feasibility level engineering assessment of the options, as detailed in Chapter 4. Although Richmond Direct appears to be the most cost effective alternative (because it avoids the high cost of developing urban infrastructure through

Petersburg) costs in the $3.1-3.3 billion range the results for all five options are very close, well within the error range of the estimates. By comparison, the original 2010 Progress Report C estimate if increased by 5% inflation to $2.87 billion is very close to this new $3.1-3.3 billion figure, which is based on a much more detailed environmental and engineering assessment than was possible in the earlier study. This difference in costs can be largely explained by the added cost of a high level James River Bridge in the five new options, which was not anticipated in the earlier 2010 cost estimates.

5. The total cost for the Hampton Roads-Washington Corridor for each option were also very similar with the total cost of Option 2A Northern Greenfield being $8.03 billion while that for Option 3 Richmond Direct is $7.83 billion. This is a cost of $38-41 million per mile (including equipment), which is much less expensive than major new interstate highway construction costs which in urban and suburban areas typically fall in the $100-200 million per mile range.[3] The cost of the rail project is held down by sharing existing rail rights of way, for example the largely abandoned "V-Line" corridor through urban areas. Although development of the rail corridor all the way to Washington D.C. would be a large project, it would have correspondingly large benefits. Its costs and affordability are not out of line with comparable highway benchmarks.

Exhibit 4-7 below breaks down the Capital Costs for a 220-mph electrified rail system from Norfolk to Washington D.C.

For Options 1A, 1B, 2A, 2B and 3, capital costs for the 130-mph diesel service were scaled based on the 220-mph estimates. At a minimum there would be some cost savings by not installing the electrification and purchasing lower cost diesel trains. If train frequencies were reduced it may be possible to single track some portions of the corridor although this was not included in the current cost estimate for 130-mph diesel service. It could be possible to save additional money by reducing the maximum speed to 110 mph and installing level grade crossings rather than grade separations. Again this was not included but if this approach were applied in the development of a diesel option, it could reduce the initial costs of developing the infrastructure.

The cost for the 130-mph diesel service was estimated by applying a factor of 73% to the 220-mph costs shown below. This factor was based on the ratio of costs calculated for 130-mph vs 220-mph service on an identical greenfield alignment by the Atlanta-Charlotte Tier I EIS Study.

Option 3 – Richmond Direct is the least expensive of all the High Speed options since it avoids the cost associated with urban infrastructure in Petersburg or Hopewell. However costs for all routes will be subject to further refinement as a part of the Tier I NEPA process. Track spacing requirements may impact the cost for options 1B and 2B that would follow part of the existing Norfolk Southern alignment. However, the Greenfield options 1A, 2A and 3 are not affected since these options do not make any use of the Norfolk Southern alignment west of Suffolk. As a result, Richmond Direct is likely to remain the most cost effective option.

[3] The new Fluor express toll lanes widening I-495 around Washington D.C. cost $138 million per mile: $1.93 Billion for 14 miles, see http://tollroadsnews.com/news/how-fluor-lane-widened-the-495-capital-beltway-from-8-to-12-lanes-interview The Intercounty Connector in Maryland (MD-200) cost $183 million per mile: $2.56 Billion for 14 miles, see http://en.wikipedia.org/wiki/Maryland_Route_200

Exhibit 4-7: 220-mph Norfolk, VA to Washington, DC Capital Costs by Option, in $2013 (thousands)

OPTION	1A- Southern GF/Petersburg	1B- NS via Petersburg	2A- Northern GF/Hopewell	2B- NS via I295/Hopewell	3- Richmond Direct	4- Richmond Direct Improved
Equipment	$590,000	$590,000	$590,000	$590,000	$590,000	$806,000
Richmond to Washington DC	$4,064,614	$4,064,614	$4,064,614	$4,064,614	$4,064,614	$4,064,614
Newport News to Richmond	$0	$0	$0	$0	$0	$920,337
Norfolk to Richmond	$3,370,106	$3,312,754	$3,372,195	$3,286,623	$3,173,244	$3,173,244
TOTAL	***$8,024,720***	***$7,967,368***	***$8,026,809***	***$7,941,237***	***$7,827,858***	***$8,964,195***
SEGMENT INFRASTRUCTURE COST:						
Harbor Park to Kilby	$599,825	$599,825	$599,825	$599,825	$599,825	$599,825
NS- Killby to Bakers Pd	$0	$1,256,279	$0	$1,256,279	$0	$0
NS- Bakers Pd to Collier	$0	$308,389	$0	$0	$0	$0
NS- Bakers Pd to I295	$0	$0	$0	$261,039	$0	$0
SG- Kilby to Collier	$1,622,021	$0	$0	$0	$0	$0
SG- Collier to Woods Edge	$179,444	$179,444	$0	$0	$0	$0
ESG- Woods Edge to Fulton GW	$833,161	$833,161	$0	$0	$0	$0
Fulton to Main St Station	$135,656	$135,656	$135,656	$135,656	$135,656	$135,656
NG-Kilby to Proctors Bridge Rd	$0	$0	$648,346	$0	$648,346	$648,346
NG-Proctors Bridge Rd to I295	$0	$0	$954,545	$0	$0	$0
NG- I295 through Hopewell	$0	$0	$60,970	$60,970	$0	$0
I295 Oakland Blvd to RIC Apt	$0	$0	$827,843	$827,843	$0	$0
RICHMOND Apt to Fulton GW	$0	$0	$145,011	$145,011	$145,011	$145,011
RICH DIR- Proctor Br Rd to RIC Apt	$0	$0	$0	$0	$1,644,407	$1,644,407
Norfolk to Richmond Subtotal . . .	***$3,370,106***	***$3,312,754***	***$3,372,195***	***$3,286,623***	***$3,173,244***	***$3,173,244***

**** Newport News to Richmond in Option 4 is based on 130-mph High Speed Diesel Technology. Norfolk – Richmond – Washington D.C. would be all electrified. Option 4 assumes that diesels will run under the wire from Roxbury to Richmond to Washington D.C.***

4.5 CAPITAL COST BENCHMARKING

Exhibit 4-8 shows a benchmarking cost comparison of the cost estimates for the two Peninsula segments to diesel segment costs that have been developed by other studies. For comparison, all costs are normalized to $2013. It can be seen that HRTPO 90-mph Peninsula upgrades ($8.9 M/mile) cost is nearly twice DRPT's plan ($4.8 M/mile) for full capacity mitigation and grade crossing improvements (not grade separations) along the shared CSX corridor, east of Toano. As a greenfield, the Toano-Roxbury segment costs more than other diesel comparable segments, but still less expensive per mile than electrified greenfield sections such as Richmond Direct at $34.2 M/mile.

Exhibit 4-8: Engineering Costs per Mile, Diesel Options Comparison[4]

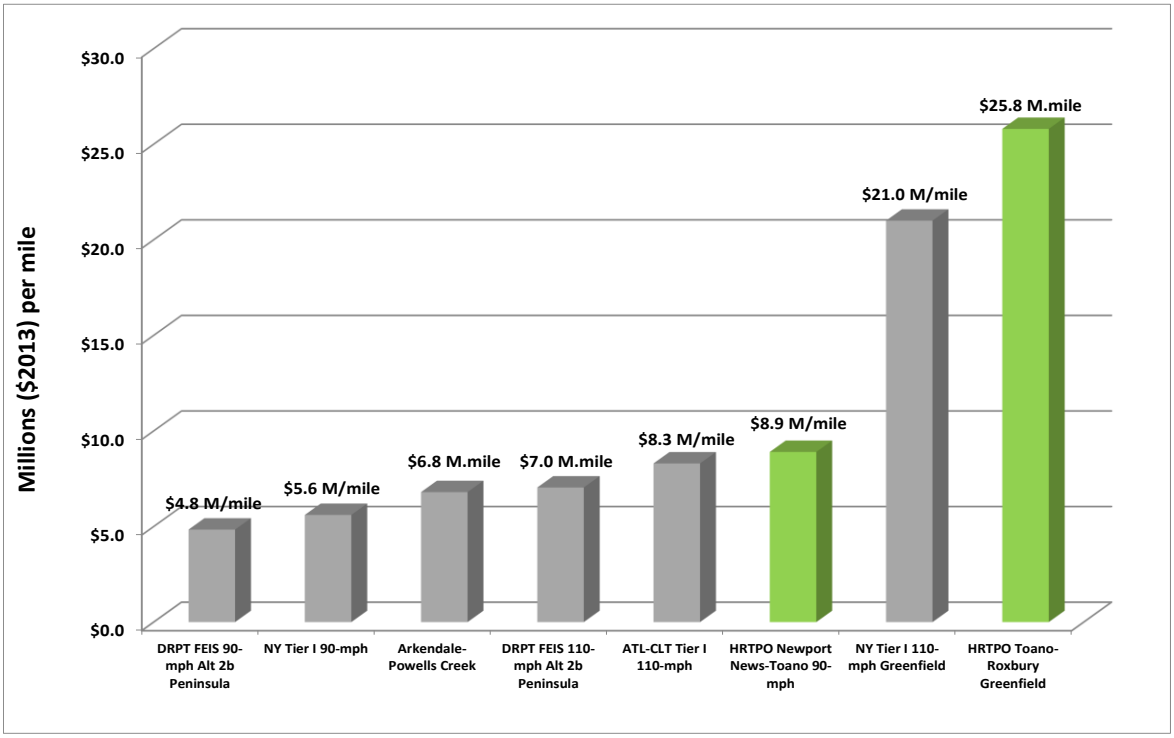
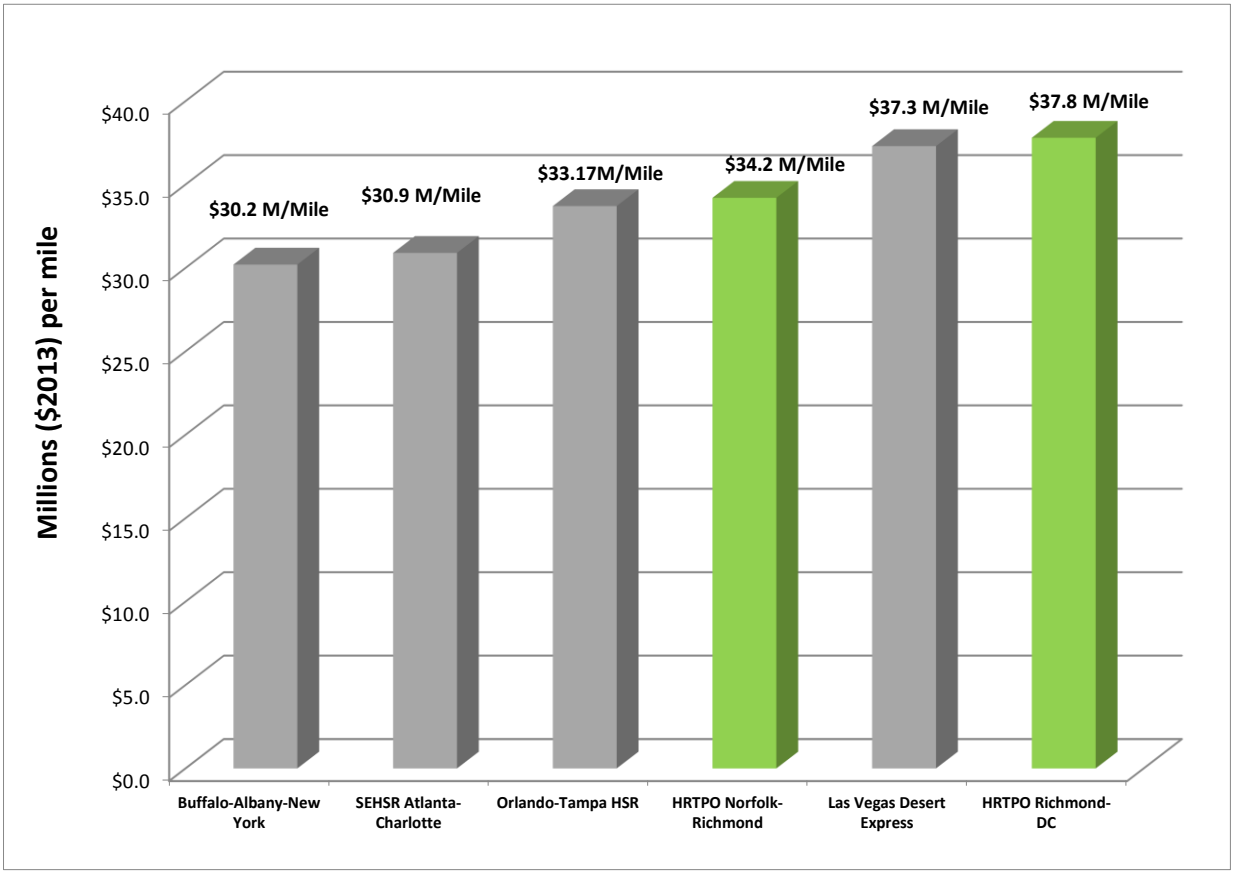


Exhibit 4-9 shows a benchmarking cost comparison of the Norfolk-Richmond and Richmond-Washington DC to electric segment costs that have been developed by other studies. All costs are normalized to $2013. It can be seen that the Norfolk-Richmond segment has mid to high-range costs, despite mostly rural infrastructure and the availability of abandoned "V-Line" facilitating a relatively low-cost approach into downtown Norfolk. Richmond-Washington D.C. costs are even higher, in spite of the relatively low cost of adding track to the existing CSX alignment north of Aquia. This is because of the high cost of the urban segments for gaining access to downtown Richmond, as well as the high cost of Long Bridge project for 4-tracking the access into downtown Washington D.C., which has now been included in the cost estimate for this segment. Additionally, a $100 million placeholder for an equipment maintenance base has been included as part of the Washington D.C. segment, and this also raises the average cost of that segment.

[4] Sources: *Hampton Roads Passenger Rail Vision Plan Alternatives Analysis*, TEMS, 2014; *Richmond to Hampton Roads Passenger Rail Project , Final Environmental Impact Statement*, DRPT, August 2012; *High Speed Rail Empire Corridor Program, Tier 1 Draft EIS*, New York State DOT; Arkendale to Powell's Creek, http://www.hrtpo.org/uploads/docs/Presentation%206%20-%20HRTPO%20Rail%20Committee_DRPT.pdf, p18.; *Atlanta to Charlotte Passenger Rail Corridor EIS*, HNTB, 2013

Exhibit 4-9: Engineering Costs per Mile, Electric Options Comparison[5]



As such the overall costs per mile developed here are seen to be within range of average costs developed by other studies. This is because new greenfield alignment is only proposed in rural areas, where it is cost effective to construct, while existing rail alignments are upgraded for gaining access to the central cities. This is the same cost-effective development strategy for High Speed rail that has been successfully employed in Europe -- where new greenfield alignments link the major cities, but the existing tracks are used to bring High Speed trains into the downtown rail stations.

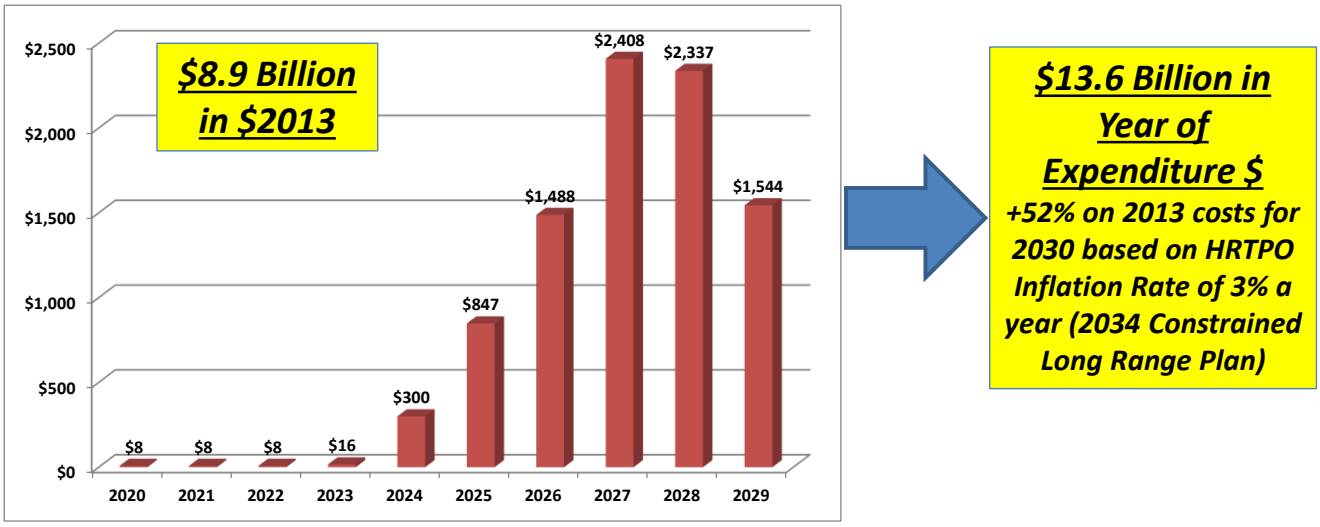
[5] See: Hampton Roads Passenger Rail Vision Plan Alternatives Analysis, TEMS, 2014; [2] High Speed Rail Empire Corridor Program, Tier 1 Draft EIS, New York State DOT; Atlanta to Charlotte Passenger Rail Corridor EIS, HNTB, 2013; Orlando-Tampa HSR, http://www.tampabay.org/high-speed-rail ; Las Vegas Desert Express, http://www.xpresswest.com/pdf/XpressWest_Media_Kit.pdf

4.6 IMPLEMENTATION, FUNDING NEEDS AND YEAR-OF-EXPENDITURE ANALYSIS

Year of Expenditure (YOE) dollars are dollars that are adjusted for inflation from the present time to the expected year of construction. Planning regulations require that revenue and cost estimates in the MTP, STIP, and TIP prepared by Metropolitan Planning Organizations, must use inflation or growth rate(s) to reflect "year of expenditure dollars," based on reasonable financial principles and information, developed cooperatively by the State, MPOs, and public transportation operators. [23 CFR § 450.216(l), § 450.322 (f)(10)(iv), and § 450.324(h)] Year of expenditure cost estimates should also be used in NEPA documentation.[6]

Accordingly, HRTPO requested that the Capital Cost for Option 4 be express in YOE dollars based on a 2030 implementation date. This calculation is based on a 3% annual inflation rate assumption between now and 2030 and results in a total project cost of $13.6 Billion in YOE dollars as compared to $8.9 Billion in current dollars. This is useful for projecting the actual funding requirement that would be needed to finance construction of the system in the future. This same distribution of capital cost is also used in the discounting (Net Present Value) calculations associated with estimation of the Benefit Cost ratios in Chapter 7.

Exhibit4-10: Capital Spend Plan and Year-of-Expenditure Cost



[6] See: http://www.fhwa.dot.gov/ipd/project_delivery/resources/financial_plans/guidance.aspx and http://www.fhwa.dot.gov/planning/tpr_and_nepa/tprandnepasupplement.pdf

5. OPERATING PLAN AND COSTS

This chapter describes the development of an operating plan for each route, the mechanism for estimating operating cost and gives the final operating cost for each option.

5.1 OPERATING PLAN

5.1.1 INTERACTIVE ANALYSIS PROCESS

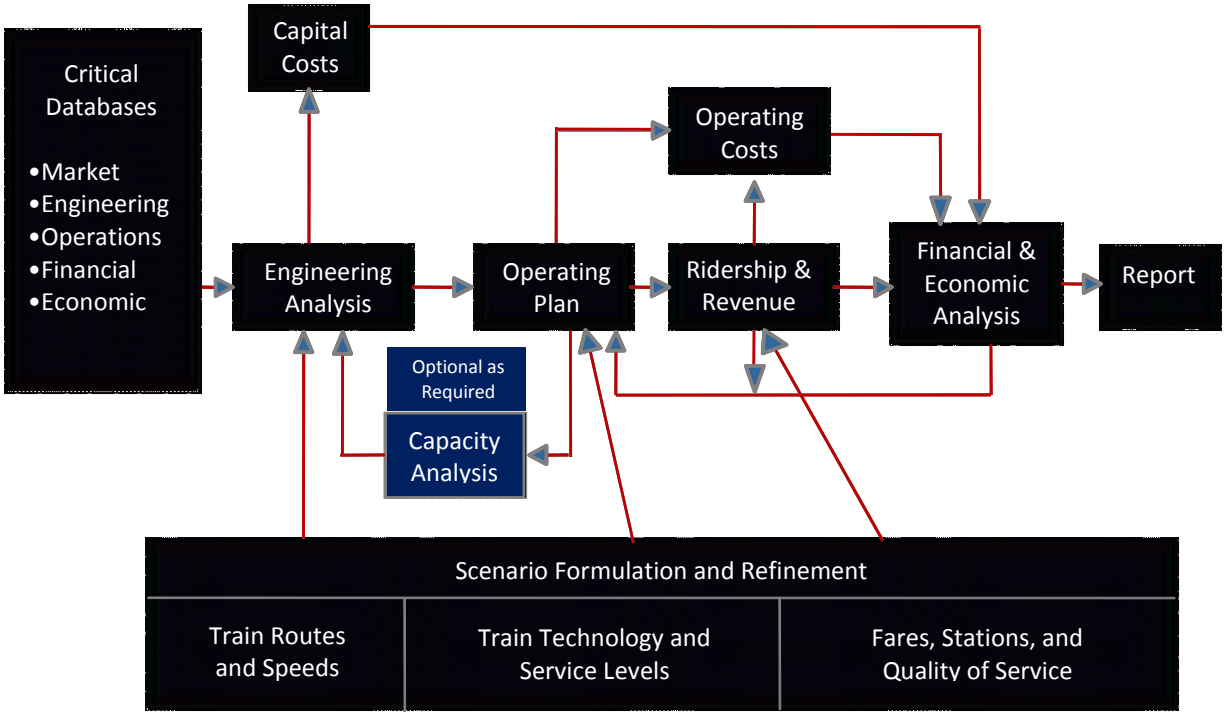
A key element for developing an operating plan is the technology selection from the range of alternative technologies available. In the case of the slower speed alternatives (79-110 mph), the most effective option is using existing railroad rights-of-way and where the volume of freight rail traffic is limited, to share tracks with freight traffic. As speeds and frequency of passenger rail service increase, the ability to share tracks with freight becomes more limited, although if wide enough the right-of-way may still be shared. For very high speeds the ability to even use existing railroad rights-of-way is typically lost. Of course, sharing track or using freight rail right-of-way may still occur (at lower speeds) in urban areas to gain access to downtown stations, but away from the urban area true high speed service is likely to require a greenfield route – since high speed rail operations need long stretches of straight track and very gentle curves to achieve high speed. Even sharing Interstate highway right-of-way may not be possible at full speed since highways frequently have curves that are too tight for the faster trains. In general, faster systems have fewer stops. A compromise may be needed to ensure all key communities are served, but this results in a trade-off between end-to-end speed and connecting communities. Each station stop takes three to seven minutes (including deceleration, stop time and acceleration back to speed) so multiple stops soon dramatically increase end-to-end running times.

Given that reasonable high speed rail routes can be developed then the key issue is the technology to be used. In the earlier Chapter 2, the representative routes are discussed. This chapter focuses on the following issues for speeds greater than 90 mph:

- Generic technology categories,
- *LOCOMOTION™* equipment database that was collected for the generic trains

As seen in Exhibit 5-1 of the interactive analysis process, train routes and speeds; technology and service levels; and fares; stations; and quality of service are all critical inputs in the operating plan process. *LOCOMOTION™* is the software used to calculate train travel times, train schedules for train alternatives, and to recommend train technology and rail system operating strategies. A key requirement for the analysis is to adjust the train size and frequency levels to appropriately match demand, providing enough capacity while still producing acceptable load factors, and respecting the financial constraints on the operation of the system. The results of the interactive analysis are then used to identify the system operating costs.

Exhibit 5-1: Interactive Analysis Process



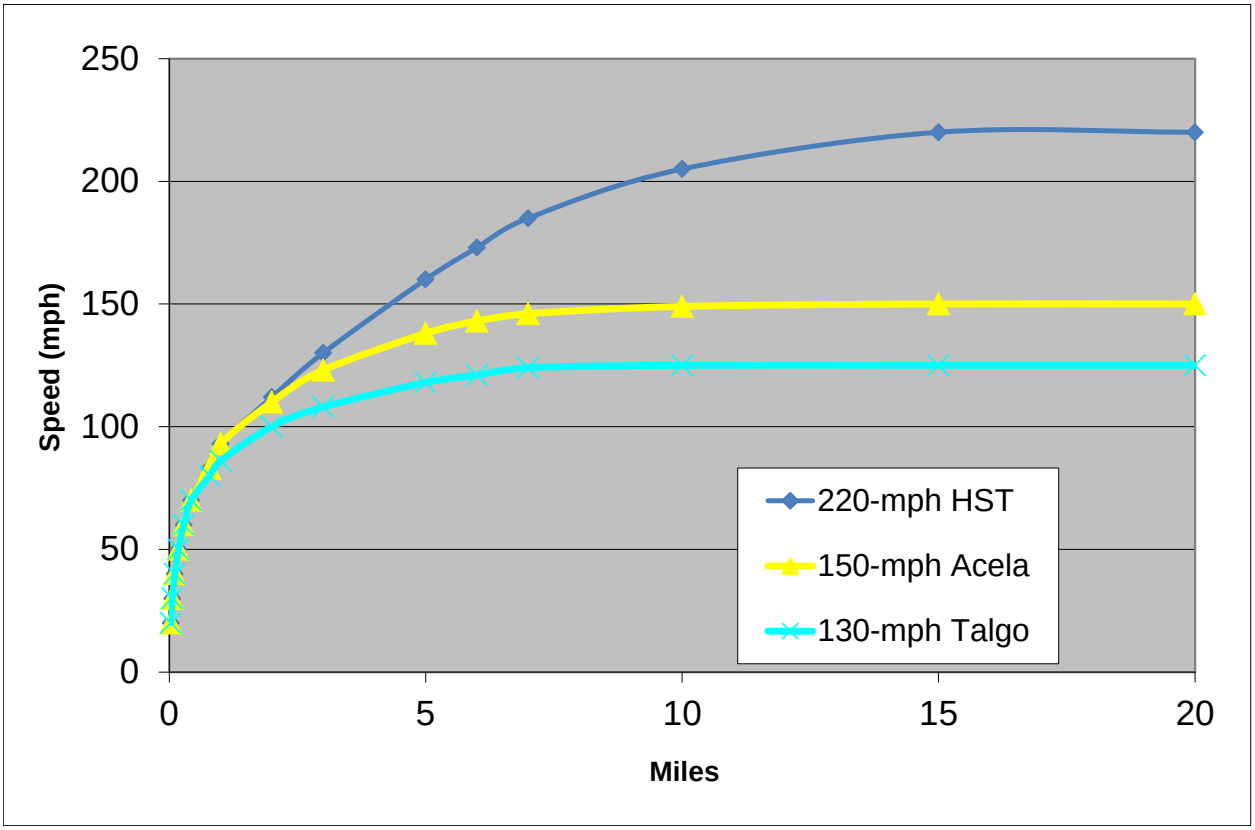
5.1.2 TRAIN TECHNOLOGY OPERATING CHARACTERISTICS

In terms of assessing rail technologies, there are two main criteria that need to be considered: type of propulsion and source of power:

- **Type of Propulsion: Trains can be either locomotive-hauled or self-propelled.** Self-propelled equipment has each individual railcar powered whereas conventional coaches rely on a separate locomotive to provide the power.
- **Source of Power: Trains can be either diesel or electrically-powered.** Diesel or electric power can be used with either the locomotive hauled or self-propelled equipment options. (Turbine power has also been considered for high speed trains, but does not offer any clear advantage over diesel at this time.)

As a rule, diesel locomotives are heavier than electric locomotives, because of the weight of the engine and also of the fuel. Electric equipment also can be more powerful since it is not limited by the on-board generating capacity of the engine. Train performance curves for representative equipment types are shown in Exhibit 5-2. The curves reflect the acceleration capabilities of three rail technologies with speed 130 mph, 150 mph and 220 mph.

Exhibit 5-2: Comparative Train Acceleration Curves[1]



Purpose-built diesel higher-speed trains, such as the Talgo T21, can offer considerably improved performance over conventional diesel trains that are based on freight-derived designs. Conventional locomotive-hauled diesel trains have a practical top speed of about 100 mph, whereas purpose-built high speed diesel trains can achieve 125 mph to 135 mph and can accelerate much faster than a conventional diesel train. For speeds above 135 mph, electrified trains are needed. Some European diesel-powered 125-mph trains offer up to 500 seats, but if U.S. safety regulations were applied, the added vehicle weight (10-15 percent) would likely reduce the practical capacity of such trains down to 400-450 seats.

Up to its current top speed of 150 mph, Exhibit 5-2 shows that the Acela accelerates as fast as a TGV due to its very high power to weight ratio. This implies that the Acela could go even faster if it were given a straight enough track to run on. Acela's weight penalty however, expresses itself in terms of a higher operating cost and lower revenue generating capacity than a comparable TGV. However, this is not a serious problem in the special environment in which the Acela operates (i.e., limited capacity and a very high level of demand.

The following train technologies are described in Exhibit 5-2:

- **130-mph Talgo T21:** the technical characteristics are hauled (non-powered) axles equipped with independent wheels to prevent hunting movement and to reduce wheel-track interaction;

[1] Source: TEMS LOCOMOTION™ Equipment Database showing typical technology performance parameters, as developed and validated over the course of previous rail studies.

Permanently steered axles by means of robust guiding bars that keep the wheels parallel to the track at all times; high-comfort tilting suspension, with natural car body tilting toward the interior of curves; Articulated couplings between adjacent cars with anti-overturning and anti-vertical hunting mechanisms; and maximum commercial speed of 140 mph[2].

- **160-mph Acela:** Acela express with standard gauge of 1,435 mm (4 ft 8 1/2 in) and maximum operating speed 160 mph (256 km/h). However since Amtrak decided not to order any more Acela equipment and instead will purchase new trains in a joint procurement with California, this category of trains will not be used here. Instead, the 220-mph category of electric train will be used.
- **220-mph AGV:** The trains that are certified to run 220-mph speed include Siemens Valero, Bombardier Zefiro, and Alstom AGV. Chinese HST are even faster with speeds up to 240 mph. The trains are constructed from units comprising three cars, each with one transformer and two traction electronics packages located underneath the cars, and from single-car trailers. A 7-car unit has two 3-car modules separated by one trailer and seating for around 245, an 11-car unit has three 3-car modules with two trailer cars with seating for around 446. The maximum commercial speed is 360 km/h (220 mph)[3].

Exhibit 5-3 below summarizes the train characteristics.

Exhibit 5-3: Train Characteristics Table

Conventional	Higher Speed	High Speed	
▪ 79 mph	▪ 110 mph	▪ 160 mph	▪ 220 mph
▪ Diesel	▪ Diesel	▪ Electric	▪ Electric
▪ Non-Tilting	▪ Tilting	▪ Tilting	▪ Non-Tilting
▪ NEC Regional	▪ Acela Express	▪ Talgo T21	▪ AGV

The key tool used for development of pro-forma train schedules is the *LOCOMOTION™* Train Performance Calculator. *LOCOMOTION™* works in conjunction with a *TRACKMAN™* infrastructure database to estimate train speed given various types of track geometry, curves, gradients and station-stopping patterns. The *TRACKMAN™* database captures all the details of grades, curves, superelevation, speed limits and station locations along the line. *LOCOMOTION™* then calculates the train running time for each route segment and sums the running times to produce a timetable. *LOCOMOTION™* assumes a train will accelerate to a maximum possible speed and will only slow down for stations or speed restrictions due to curves, crossings, tunnels or civil speed restrictions such as grade crossings and sensitive urban areas.

The inputs for *LOCOMOTION™* consist of milepost-by-milepost data (as fine as 1/10th of a mile) defining gradient and curve conditions along the track. For this study, these data were derived from a condensed profile for existing rail alignments and the use of field inspection data along with satellite photography and GIS mapping to develop the geometry for new routes.

In addition, *LOCOMOTION™* includes a train technology database that defines the acceleration, top speed, and braking characteristics of each train technology type. The database includes many train types with

[2] http://www.talgo.com/pdf/TXXIen.pdf
[3] http://en.wikipedia.org/wiki/Automotrice_%C3%A0_grande_vitesse

varying performance characteristics, ranging from heavy freight trains all the way up through very high speed rail options.

Train timetables are determined from running times and are used to calculate rolling stock requirements. Train frequencies and the number of cars required per train are determined via an interactive process using the demand forecast *COMPASS™* model.

The results taken from *LOCOMOTION™* will be faster than the actual times, since they are based on optimized performance of trains under ideal conditions. While it is assumed that passenger trains will have dispatching priority over freight, practical schedules still need to allow 5-10 percent slack time in case of any kind of operating problem, including the possibility of freight or commuter train interference, depending on the degree of track sharing with freight. Slack time is included in the train timetables and in the input provided to the *COMPASS™* model.

5.1.3 TRAIN TIMETABLES – NORFOLK TO WASHINGTON D.C. ONLY – OPTIONS 1A, 1B, 2A, 2B AND 3

As background, Exhibit 5-4 shows the train schedule objectives that were developed for Hampton Roads service, as Exhibit B-6 on page B-13 of the earlier 2010 study ***Progress Report B***. The detailed update performed here has validated this earlier work since the newest schedules are still consistent with these earlier results. However, this study has only updated Steps 3 and 4 for the Richmond to Norfolk segment – the two cells highlighted in yellow in Exhibit 5-4 below. Please note that the diesel train top speeds in Steps 3 and 4 have subsequently been raised from 110 mph to 130 mph in the current study; electric train speeds in Step 4 raised from 150 mph to 220 mph. All other train schedule assumptions have been carried forward from the previous study.

The original Phase 2(B) study developed two speed options: 130 mph and 220 mph, for each of the five Norfolk route options 1A, 1B, 2A, 2B and 3. All of these options assumed only the existing Amtrak service on the Peninsula with the addition of one more train, bring the assumed Amtrak frequency to 3 Newport News round trips.

A key output of the Operations Planning process has been the operational train schedules, based on an assumed train frequency, stopping patterns and running times. These key results are presented in Exhibit 5-5 through 5-14. These exhibits summarize the key train scheduling assumptions that were using as a direct input to the ridership forecasting process.

For implementation of both conventional and high speed rail to be efficient, it is essential to improve train schedules and frequencies in a balanced way. Typically as speeds increase, the market expands and both train size and frequency also need to be increased. The proposed implementation steps add train frequency as speeds increase in a manner that is reflective of the growth in market demand, and also equitably scaled to the relative size of the north and south side demographic bases.

Exhibit 5-4: Schedule Objectives for Hampton Roads Service from Phase 1 Progress Report B

	Step 1		Step 2		Step 3		Step 4	
	Conventional Amfleet	Conventional Amfleet	Conventional Amfleet	Diesel HST	Conventional Amfleet	Diesel HST	Diesel HST	Electric HST
	79-mph	79-mph	79-mph	90-mph	90-mph	110-mph	110-mph	150-mph
Washington to Richmond	2:45[1]	2:15[2]	2:20[3]	2:05	2:20	1:30	1:30	1:05
Richmond to Norfolk		1:48		1:48[5]		1:10		0:55
Richmond to Newport News	1:25		1:25		1:13		0:52	
Total	4:10	4:03	3:45	3:53	3:33	2:40	2:22	2:00[4]

1 2:45 current Amtrak time to Main Street, 1:35 to Newport News
2 2:15 current Amtrak time to Staples Mill Road Station only, does not go to Main Street
3 2:20 to Main Street, train operates at 90 mph north of Richmond
4 2:00 proposed schedule objective for HSR electric service
5 1:38 using 79 mph south of Petersburg

In the 2010 study, schedule times were based on the train types shown and assume expected levels of infrastructure upgrade associated with each Step. Train times in Step 1 are consistent with current Amtrak schedules and with the Richmond/Hampton Roads Passenger Rail Project DEIS projection for 79-mph Richmond to Norfolk service. Times in Step 2 are consistent with the DEIS.

Washington to Richmond times for Norfolk service in Step 2 does reflect an improvement from 2:20 down to 2:05 assuming the use of high speed diesel trains[4] rather than conventional Amtrak equipment. This is consistent with the capabilities of locomotive hauled passive tilt trains using a very conservative 6" Cant deficiency assumption. The time is also sufficient to allow a reasonable amount of slack for co-mingled operation on shared infrastructure with freight trains.

DRPT has defined a schedule objective of 1:30 for Washington-Richmond service on existing CSXT tracks[5]. Preliminary performance modeling suggests that this might be possible, but it would require the use of very aggressive 9" of Cant Deficiency and allows for very little slack time in the schedule. A ninety-minute schedule may be theoretically possible for a DMU with active tilt, but would certainly require a dedicated track not only to minimize the possibility of freight train delays, but also to support the kind of precision

[4] This does not contradict the DEIS, since it must be recognized that Amtrak's current Amfleet coaches are already 35 years old and beyond their mid-life refurbishment. See: http://en.wikipedia.org/wiki/Amfleet. This equipment is already considered commercially obsolete and has been rejected by California, Washington and Oregon who purchased new equipment for their state-supported trains. Modern High-Speed Diesel trains are well able to satisfy the performance parameters of the DEIS offering similar or better environmental performance. Given DRPT's expected project development timeframes, the Amfleet equipment will be approaching 50 years of age by the time the project is implemented. Although Amfleet has been used to characterize the performance capabilities of existing trains, the DEIS certainly does not appear to exclude the possibility of actually purchasing new trains for the service by the time it is implemented.
[5] See: http://www.drpt.virginia.gov/studies/files/WashingtonD.C.StudyDetails.pdf

track maintenance and curve geometry that such high deficiency operations will require. A 1:30 schedule over existing tracks appears to be barely achievable and may not ultimately be deliverable in practice.[6]

In contrast, the 1:30 schedule objective shown for 130-mph high speed diesel train is achievable by assuming a Greenfield segment, using very conservative train performance assumptions even if only a *part* of the proposed greenfield alignment were complete it might enable the diesel service to comfortably attain DRPT's 90 minute schedule objective. If the entire Richmond to Aquia greenfield were completed as proposed a diesel train could complete the run in 1:05 and an electric train would need 50-55 minutes.

This leads to a potential 2:00 schedule for Norfolk to Washington D.C. 220-mph electric service and also a 2:00 schedule for Newport News to Washington D.C. 130-mph diesel service. It should be pointed out an all-electric or diesel/electric dual mode service would also eliminate the 20-30 minutes delay typically now incurred for a locomotive change in Washington, so the time savings to NEC points north of Washington would be even greater.

The rail service assumptions that were developed for Steps 3 and 4; Options 1A, 1B, 2A, 2B and 3 by the Phase 2(B) study were as follows:

- Washington D.C. to Richmond, 109 miles (Current Time 2:00, 79 mph):
    - Assumes a new conceptual greenfield due to capacity and geometric limitation of existing Right-of-Way
    - 130-mph diesel could easily achieve 1:30 on a greenfield – a very aggressive tilt train could possibly achieve this time on the existing CSX alignment
    - 220-mph electric could achieve 0:55 based on a high quality greenfield from Aquia to Richmond
- Richmond to Norfolk, 97-105 miles (Current Time 2:00, 79 mph):
    - 13 daily round trips at 130 mph for Step 3; 1:00 to 1:10 schedule times
    - 22 daily round trips at 220 mph for Step 4; 0:45 to 0:55 schedule times
- Richmond to Newport News, 75 miles (Current Time 1:25, 79 mph):
    - 3 daily round trips at 79 mph; 1:25 schedule time

Overall, the impact of the proposed improvements would be to cut Norfolk-Washington D.C. schedule time in half: from over 4 hours today at 79 mph, to 2 hours at 220 mph once the high speed rail system has been fully implemented. From Richmond to Washington D.C. the assumed running times are as shown in Exhibit 5-5. These times from Richmond to Washington D.C. are the same for all five Norfolk options 1A, 1B, 2A, 2B and 3. They are added as a constant term to the Richmond-Norfolk times for each option 1A, 1B, 2A, 2B and 3 that is presented in the subsequent exhibits.

[6] Please note that SEHSR does ***not*** use a 90-minute schedule in its planning or demand forecasting for this segment. See FAQ # 5 of http://www.sehsr.org/faq.html that projects a 2 hour Richmond to Washington D.C. schedule. Also, a 2 hour (rather than 90-minute) timetable is used in DRPT's plan for Hampton Roads service, see Table 6 of the *Richmond/Hampton Roads Passenger Rail Study, Alternatives Analysis and Tier 1 Environmental Impact Statement*, DRPT, Nov 2005: http://rich2hrrail.info/downloads/FinalAltDvpReport011706.pdf

Exhibit 5-5: Proposed Richmond to Washington D.C. Running Times

130-mph Diesel

Station	Super Express	Express	Local
Richmond Main St	0:00	0:00	0:00
Ashland			0:12
Fredericksburg		0:40	0:45
Quantico			1:08
Alexandria	1:20	1:25	1:35
Washington Union	1:30	1:35	1:45

220-mph Electric

Station	Super Express	Express	Local
Richmond Main St	0:00	0:00	0:00
Ashland			0:10
Fredericksburg		0:25	0:30
Quantico			0:45
Alexandria	0:43	0:48	0:58
Washington Union	0:53	0:58	1:08

These Richmond to Washington D.C times are consistent with the Step 3 and 4 times of 1:30 and 1:05 for Diesel and Electric options, respectively, from 2010 Progress Report B as shown in Exhibit 5-4. The 1:30 Diesel time can be achieved on the CSX alignment using aggressive tilt technology. The 220-mph electric times are based on conceptual Greenfield route options between Richmond and Washington DC.

NORFOLK TO WASHINGTON D.C.: OPTION 1 VIA PETERSBURG

Two conceptual options 1A and 1B have been defined in Chapter 2 via Petersburg. Option 1A has been defined as a "Southern Greenfield" whereas Option 1B would utilize the existing Norfolk Southern rail alignment. However, since both alignments are essentially straight and about the same length, the running times for the two route variants are extremely close – within a minute of one another – so the train schedule for either variant is the same. Schedules for the Petersburg Option 1 are shown in Exhibit 5-6, and the 130-mph and 220-mph *LOCOMOTION™* speed profiles for the two train simulations are shown in Exhibit 5-7 and 5-8.

Exhibit 5-6: Proposed Norfolk to Washington D.C. -- Option 1 Times via Petersburg

130-mph Diesel

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:12	0:12	0:12
Suffolk			0:17
Petersburg		0:53	0:58
Richmond Main St	1:04	1:09	1:14
Washington Union	2:36	2:46	3:01

220-mph Electric

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:10	0:10	0:10
Suffolk			0:15
Petersburg		0:40	0:45
Richmond Main St	0:50	0:55	1:00
Washington Union	1:45	1:55	2:10

** Allowing 2 minutes for Richmond Station Stop*

Exhibit 5-7: Norfolk to Washington D.C. -- Option 1 via Petersburg – 2:08:25 at 130 mph

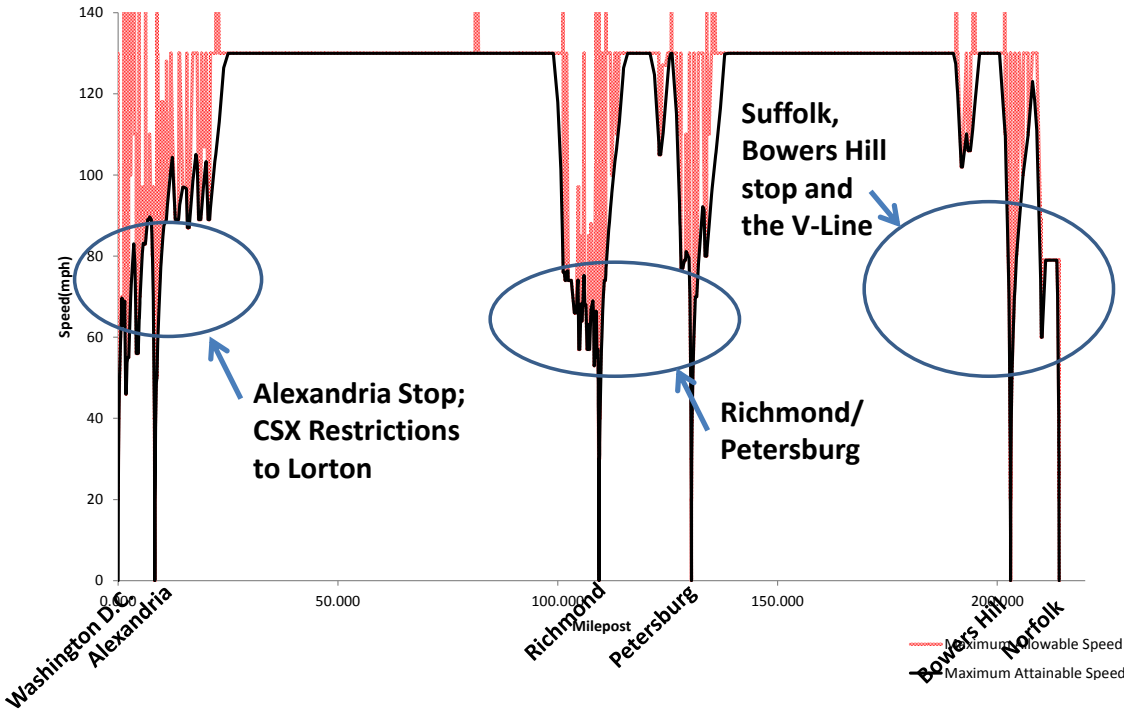
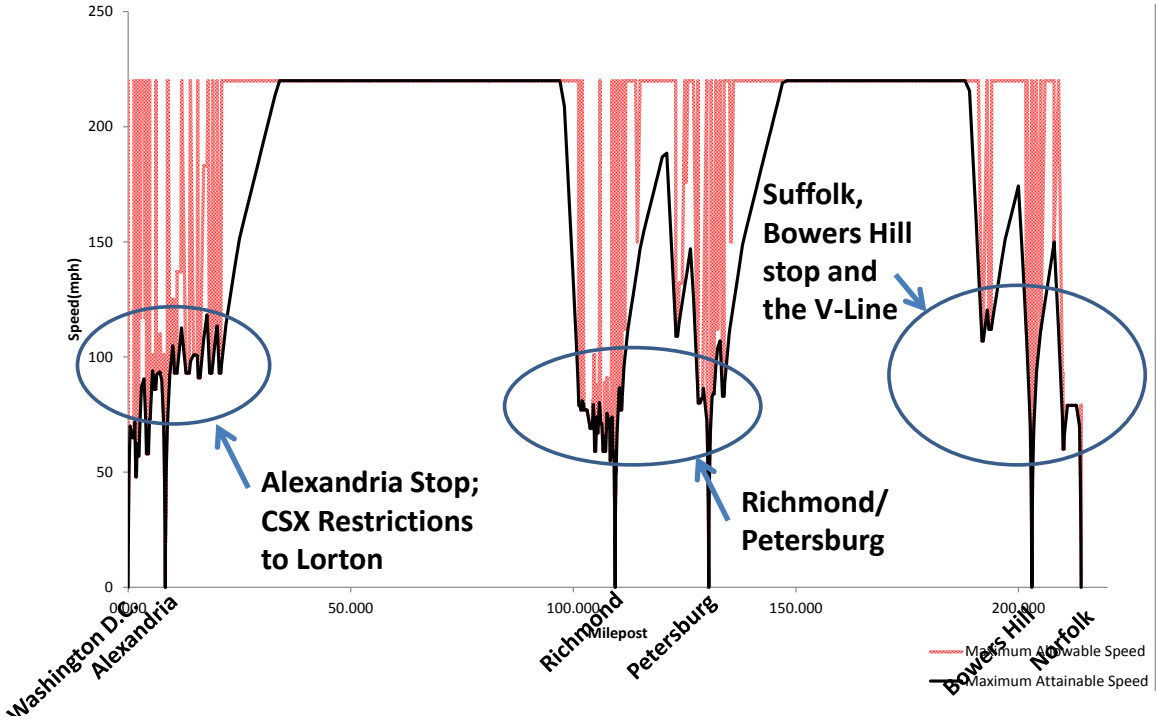


Exhibit 5-8: Norfolk to Washington D.C. -- Option 1 via Petersburg – 1:40:36 at 220 mph



NORFOLK TO WASHINGTON D.C.: OPTION 2 VIA HOPEWELL

Two conceptual options 2A and 2B have been defined in Chapter 2 via Hopewell. Option 2A has been defined as a "Northern Greenfield" whereas Option 2B would utilize the existing Norfolk Southern rail alignment. However, since both alignments are essentially straight and about the same length, the running times for the two route variants are extremely close – within a minute of one another – so the train schedule for either variant is the same. Schedules for the Hopewell Option 2 are shown in Exhibit 5-9, and the 130-mph and 220-mph *LOCOMOTION™* speed profiles for the two train simulations are shown in Exhibit 5-10 and 5-11.

Exhibit 5-9: Proposed Norfolk to Washington D.C. -- Option 2 Times via Hopewell

130-mph Diesel

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:12	0:12	0:12
Suffolk			0:17
Hopewell		0:50	0:53
Richmond Main St	1:04	1:09	1:14
Washington Union	2:36	2:46	3:01

220-mph Electric

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:10	0:10	0:10
Suffolk			0:15
Hopewell		0:37	0:42
Richmond Main St	0:50	0:55	1:00
Washington Union	1:45	1:55	2:10

** Allowing 2 minutes for Richmond Station Stop*

Exhibit 5-10: Norfolk to Washington D.C. -- Option 2 via Hopewell – 2:07:19 at 130 mph

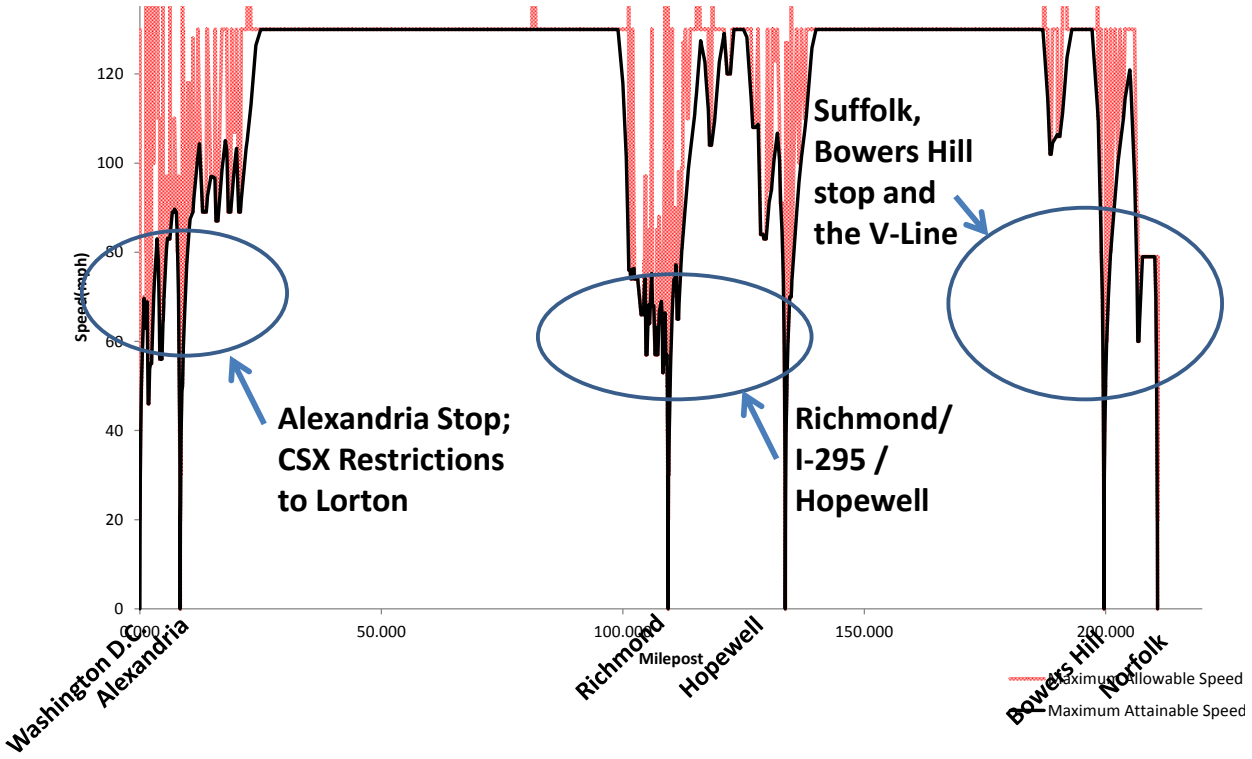
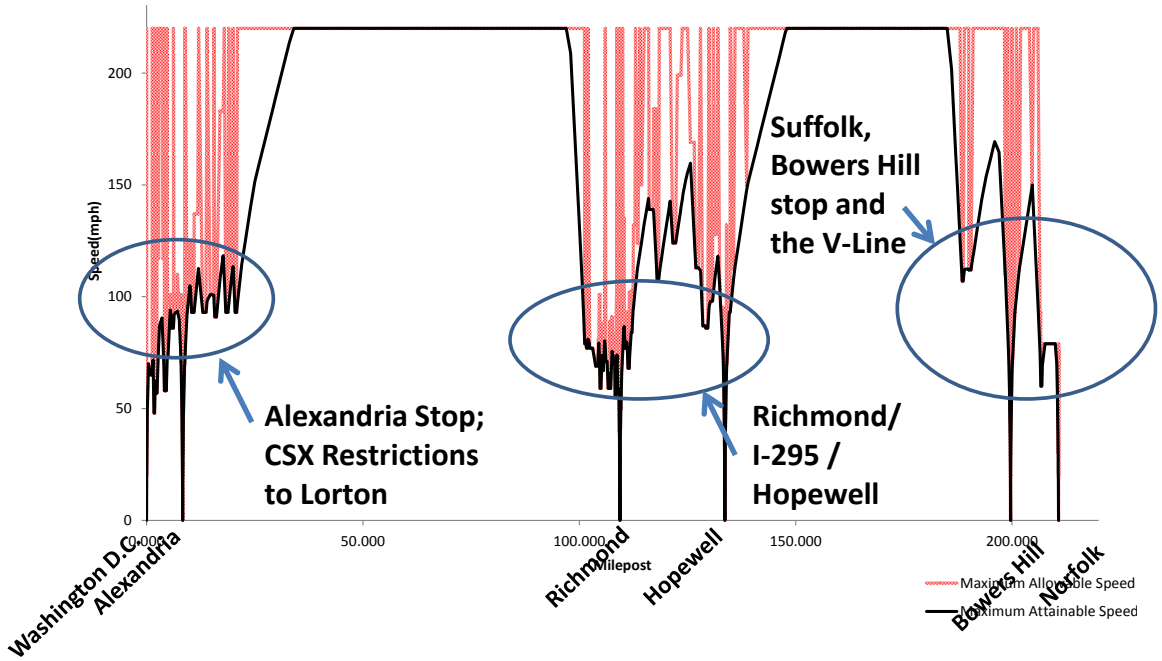


Exhibit 5-11: Norfolk to Washington D.C. -- Option 2 via Hopewell – 1:40:30 at 220 mph



NORFOLK TO WASHINGTON D.C.: OPTION 3 RICHMOND DIRECT

Schedules for the Richmond Direct Option 3 are shown in Exhibit 5-12, and the 130-mph and 220-mph *LOCOMOTION™* speed profiles for the two train simulations are shown in Exhibit 5-13 and 5-14. The Richmond Direct option is about five minutes faster than going via Petersburg or Hopewell for an express train; as compared to a stopping train, Richmond Direct is about 10 minutes faster

Exhibit 5-12: Proposed Norfolk to Washington D.C. -- Option 3 Times Richmond Direct

130-mph Diesel

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:12	0:12	0:12
Suffolk			0:17
Richmond Main St	0:59	0:59	1:04
Washington Union	*2:31*	*2:36*	*2:51*

220-mph Electric

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:10	0:10	0:10
Suffolk			0:15
Richmond Main St	0:43	0:43	0:48
Washington Union	*1:38*	*1:43*	*1:58*

** Allowing 2 minutes for Richmond Station Stop*

Exhibit 5-13: Norfolk to Washington D.C. -- Option 3 Direct – 2:07:19 at 130 mph

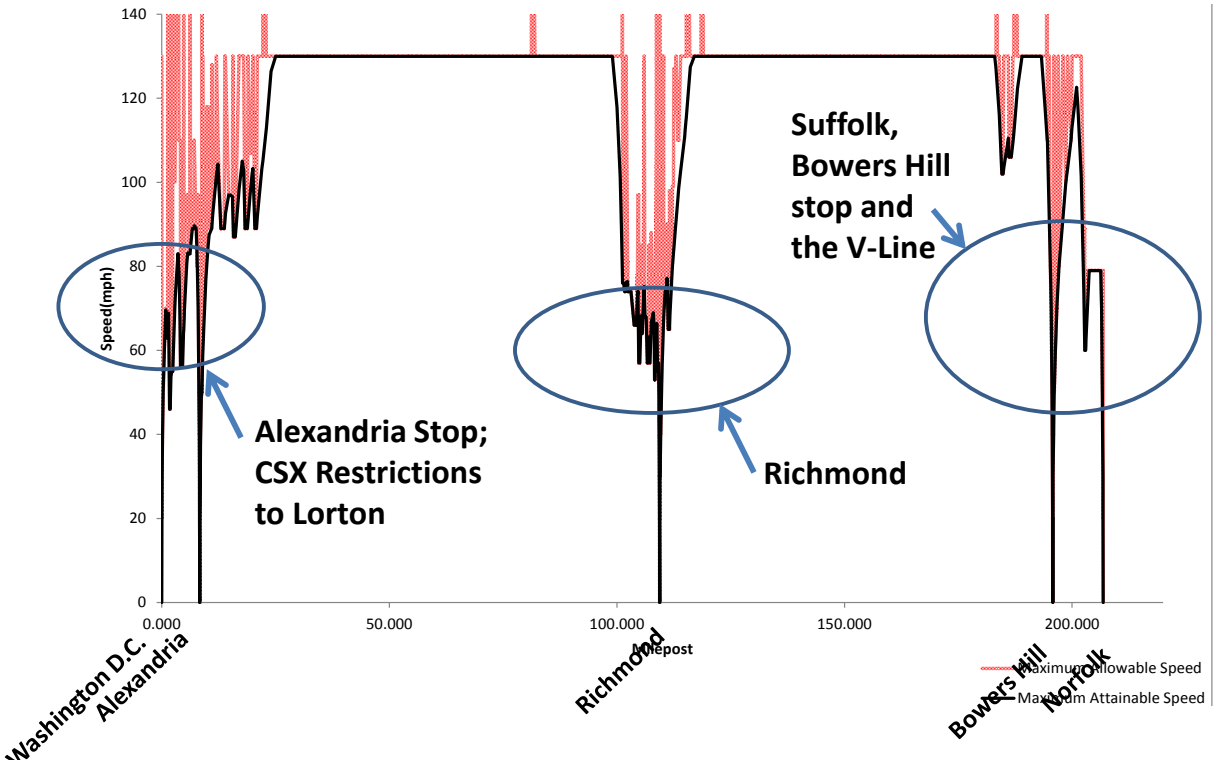
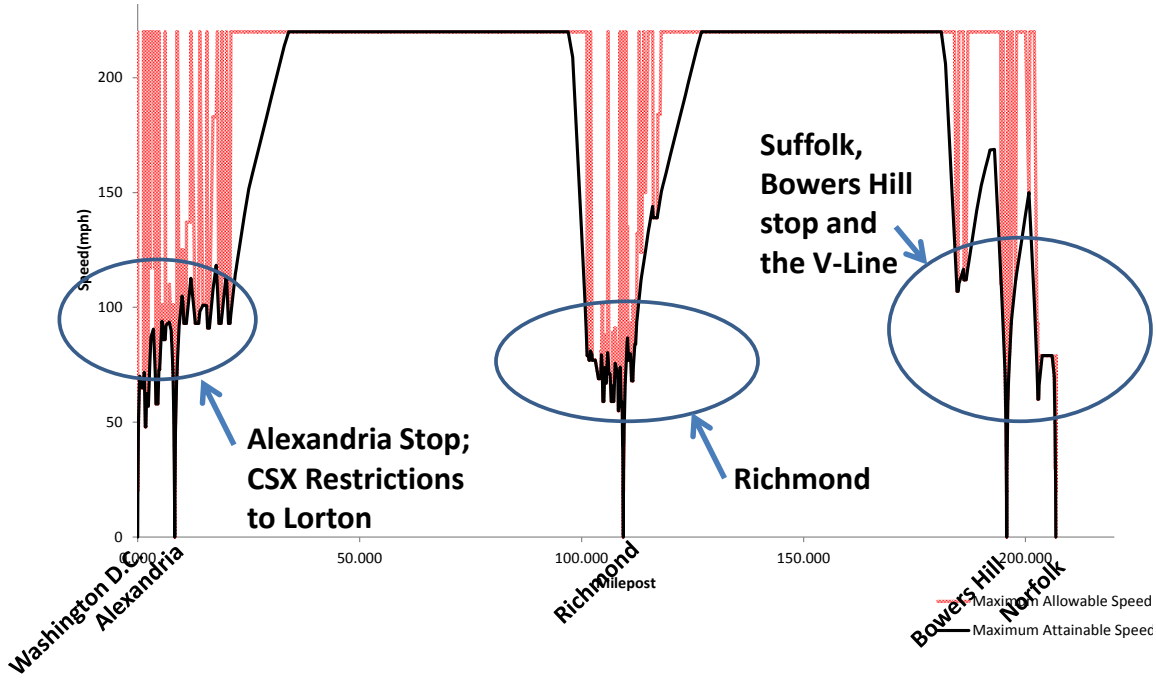


Exhibit 5-14: Norfolk to Washington D.C. -- Option 3 Direct – 1:40:30 at 220 mph



5.1.4 TRAIN TIMETABLES – ENHANCED PENINSULA SERVICE – OPTION 4

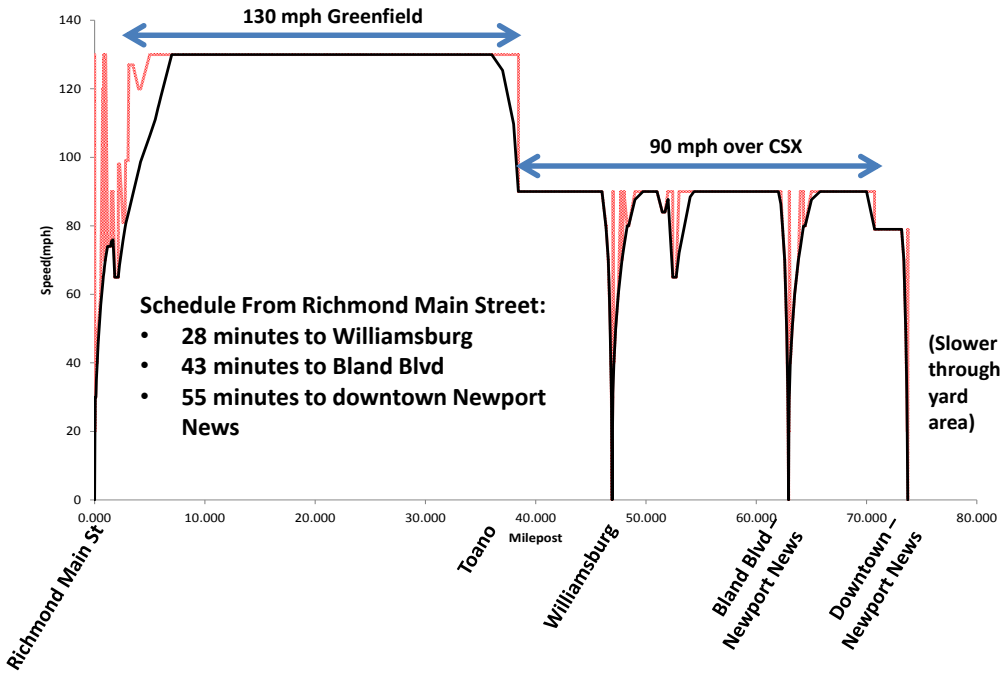
The original Phase 2(B) report suggested a sensitivity "Option 4" that would add a High Speed connecting link over to Toano, as an extension of the Richmond Direct Option 3 220-mph High Speed electric option. This would allow Peninsula diesel trains to also share a portion of the proposed Norfolk High Speed alignment. In the Phase 2(B) report this was proposed only as a sensitivity option, but in this report Option 4 has been more fully developed at a feasibility level.

Option 4 specifically assumes that 130-mph High Speed diesel trains will operate on the Peninsula (the same trains that were assumed for the Step 3 analysis) and that 220-mph electric trains will operate to Norfolk (the same trains that were assumed for the Step 4 analysis.) Option 4 thus reflects a hybrid that combines both electric and diesel technologies in a single option. This reflects the ability of 130-mph diesel trains to run "under the wire" on a 220-mph electrified track. As a result, the Peninsula rail service can substantially benefit from development of the Norfolk -Richmond-Washington D.C. High Speed line even if electrification does not extend all the way to Newport News.

As shown in Exhibit 5-15, Peninsula diesel trains would run on high quality greenfield alignment at 130-mph as far as Toano, where they would enter the existing CSX alignment and be limited to 90-mph. The schedule time from Richmond Main Street would only be 55 minutes to downtown Newport News. Coupled with a 1:05 schedule from Washington D.C. to Richmond, the timetable would be 2 hours.[7]

[7] If the Roxbury-Toano segment were electrified and dual model trains with a 220-mph top speed capability were introduced, Peninsula trains would save an additional 15 minutes and achieve a 1:45 schedule.

Exhibit 5-15: Richmond to Newport News Speed Profile



0:55 Newport News-Richmond plus 1:05 Richmond-Washington DC* = 2:00 Overall Schedule Objective
*** 1:05 Time for 130-mph diesel train based on a Greenfield alignment north of Richmond**

SCHEDULE SUMMARY

The result of this operational analysis along with recommended train frequencies for the two speed options are summarized in Exhibit 5-16. As can be seen, the overall running times via Petersburg and Hopewell are essentially the same; Richmond Direct is five to ten minutes faster.

Exhibit 5-16: Norfolk to Washington D.C. – Schedule Results Summary

Stations	Super Express	Express	Local
Norfolk	√	√	√
Bowers Hill	√	√	√
Suffolk	–	–	√
Petersburg/Hopewell*	–	√	√
Richmond Main St	√	√	√
Ashland	–	–	√
Fredericksburg	–	√	√
Quantico	–	–	√
Alexandria	√	√	√
Washington Union	√	√	√
130-mph Total Trains	4 trains	5 trains	4 trains
130-mph Time via Petersburg/Hopewell	2:36	2:46	3:01
130-mph Time Richmond Direct	2:31	2:36	2:51
220-mph Total Trains	5 trains	10 trains	3 trains
220-mph Time via Petersburg/Hopewell	1:45	1:55	2:10
220-mph Time Richmond Direct	1:38	1:43	1:58

* Stations Bypassed by Richmond Direct

In Exhibit 5-16, "Super Express" trains stop only at the main urban stations. "Express" trains add stops in Petersburg and Fredericksburg. Local trains make all stops. The schedule times of all four route options are very close. The results of this more detailed assessment support the findings of the earlier 2010 study, Progress Report B. Petersburg and Hopewell route options have the same times. These route options are 5 minutes slower than Richmond Direct, plus an additional 5 minutes if they add a stop. [8]

The overall train schedule and equipment assumption for Option 4, which provides High Speed Rail service to the southside and Enhanced service on the Peninsula, is summarized in Exhibit 5-17. Norfolk service times in Exhibit 5-17 are the same as shown for Richmond Direct in Exhibit 5-16.

[8] Although every minute of time savings attracts more riders, the time difference between options is not enough to drive significant differences in ridership between the options. Going via Petersburg or Hopewell would add ridership from this intermediate market but the added time would marginally reduce ridership from Norfolk and Bowers Hill. As a result, the route selection will likely be made based on cost, environmental factors and synergies with other routes, including the relative degree of benefit to the Peninsula and SESHR services and the degree to which the Peninsula and SEHSR ridership is responsive to such benefits.

Exhibit 5-17: Option 4 Schedule Summary

Electric HST 160-220 mph

- ***Used for Southside***
- ***Speeds up to 220-mph on dedicated high speed ROW***
- ***79-mph on NS; 90-mph on CSX ROW****

Diesel HrST 90-130 mph

- ***Used for Peninsula***
- ***Speeds up to 130-mph on dedicated high speed ROW***
- ***79-mph on NS; 90-mph on CSX ROW****

Timetable	WAS-NRF 220-mph Super Express 5 Stops to DC	WAS-NRF 220-mph Express 7 Stops to DC	WAS-NRF 220-mph Local 10 Stops to DC	WAS-NPN 130-mph Express 7 Stops to DC	WAS-NPN 130-mph Local 10 Stops to DC
Total Trains	5 trains	10 trains	3 trains	4 trains	4 trains
Schedule Time	1:38	1:43	1:58	2:00	2:10

** Maximum Speeds for Sharing Freight Rail Rights of Way in accordance with Railroad Letters of Principle*

5.2 Operating and Maintenance Costs

5.2.1 Operating and Maintenance Costs Methodology

This section describes the build-up of the unit operating costs that have been used in conjunction with the operating plans, to project the total operating cost of each corridor option. A costing framework originally developed for the Midwest Regional Rail System (MWRRS) was adapted for use in this study. Following the MWRRS methodology[9], nine specific cost areas have been identified. As shown in Exhibit 5-18, variable train-mile driven costs include equipment maintenance, energy and fuel, and train and onboard (OBS) service crews. Passenger miles drive insurance liability, while ridership influences marketing, and sales. Fixed costs include administrative costs, station costs, and track and right-of-way maintenance costs. Signals, communications and power supply are included in the track and right-of-way costs.

This framework enables the direct development of costs based on directly-controllable and route-specific factors, and allows sensitivity analyses to be performed on the impact of specific cost drivers. It also enables direct and explicit treatment of overhead cost allocations, to ensure that costs which do not

[9] Follow the links under "Midwest Regional Rail Initiative (MWRRI)" at http://www.dot.state.mn.us/planning/railplan/studies.html

belong to a corridor are not inappropriately allocated to the corridor, as would be inherent in a simple average cost-per-train mile approach. It also allows benchmarking and direct comparability of HRTPO costs with those developed by other high speed rail studies across the nation, including those with which the proposed corridor route would connect.

Exhibit 5-18: Operating Cost Categories and Primary Cost Drivers

Drivers	Cost Categories
Train Miles →	Equipment Maintenance Energy and Fuel Train and Engine Crews Onboard Service Crews
Passenger Miles →	Insurance Liability
Ridership and Revenue →	Sales and Marketing
Fixed Cost →	Service Administration Track and ROW Maintenance Station Costs

For development of costs, since there are a number of different corridor and technology options, it is essential to maintain consistency of the costing basis across all options. For developing a fair comparison:

- Unit Costs that depend on the propulsion/speed should reflect legitimate differences between technologies and routes; and
- Unit Costs that do not depend on propulsion/speed should remain the same across all technologies and routes.

Operating costs can be categorized as variable or fixed. As described below, fixed costs include both Route and System overhead costs. Route costs can be clearly identified to specific train services but do not change much if fewer or additional trains were operated.

- Variable costs change with the volume of activity and are directly dependent on ridership, passenger miles or train miles. For each variable cost, a principal cost driver is identified and used to determine the total cost of that operating variable. An increase or decrease in any of these will directly drive operating costs higher or lower.
- Fixed costs are generally predetermined, but may be influenced by external factors, such as the volume of freight tonnage, or may include a relatively small component of activity-driven costs. As a rule, costs identified as fixed should remain stable across a broad range of service intensities. Within fixed costs are two sub-categories:
  - Route costs such as track maintenance, train control and station expense that, although fixed, can still be clearly identified at the route level.
  - Overhead or System costs such as headquarters management, call center, accounting, legal, and other corporate fixed costs that are shared across routes or even nationally. A portion of overhead cost (such as direct line supervision) may be directly identifiable but

most of the cost is fixed. Accordingly, assignment of such costs becomes an allocation issue that raises equity concerns. These kinds of fixed costs are handled separately.

Operating costs have been developed based on the following premises:

- Based on results of recent studies, a variety of sources including suppliers, current operators' histories, testing programs and prior internal analysis from other passenger corridors were used to develop the cost data. However, as the rail service is implemented, actual costs will be subject to negotiation between the passenger rail authority and the contract rail operator(s).
- Freight railroads will maintain track and right-of-way that they own, but ultimately, the actual cost of track maintenance will be resolved through negotiations with the railroads. For this study, a track maintenance cost model will be used that reflects actual freight and passenger railroad cost data.
- Maintenance of train equipment will be contracted out to the equipment supplier.
- Train operating practices follow existing work rules for crew staffing and hours of service. Average operating expenses per train-mile for train operations, crews, management and supervision were estimated through a bottoms-up staffing approach based on typical passenger rail organizational needs.

The MWRRS costing framework was developed in conjunction with nine states that comprised the MWRRS steering committee and with Amtrak. In addition, freight railroads, equipment manufacturers and others provided input to the development of the costs. However, the costing framework has been validated with recent operating experience based on publicly available data from other sources, particularly the Midwest 403B Service trains Northern New England Passenger Rail Authority's (NNEPRA) Downeaster costs and data on Illinois operations that was provided by Amtrak. It has been brought to a $2013 costing basis and additional cost categories not included in the original MWRRS study, such as for electrification, have been added into the framework.

The original concept for the MWRRS was for development of a new service based on operating methods directly modeled after state-of-the-art European rail operating practice. Along with anticipated economies of scale, modern train technology could reduce operating costs when compared to existing Amtrak practice. In the original 2000 MWRRS Plan, European equipment costs were measured at 40 percent of Amtrak's costs. However, in the final MWRRS plan that was released in 2004, train-operating costs were significantly increased to a level that is more consistent with Amtrak's current cost structure. However, adopting an Amtrak cost structure for financial planning does not suggest that Amtrak would actually be selected for the corridor operation. Rather, this selection increases the flexibility for choosing an operator without excluding Amtrak, because multiple operators and vendors will be able to meet the broader performance parameters provided by this conservative approach.

5.3 VARIABLE COSTS

These costs include those that directly depend on the number of train-miles operated or passenger-miles carried. They include train equipment maintenance, train crew cost, fuel and energy, onboard service, and insurance costs.

TRAIN EQUIPMENT MAINTENANCE

Equipment maintenance costs include all costs for spare parts, labor and materials needed to keep equipment safe and reliable. The costs include periodical overhauls in addition to running maintenance. It also assumes that facilities for servicing and maintaining equipment are designed specifically to accommodate the selected train technology. This arrangement supports more efficient and cost-effective maintenance practices. Acquiring a large fleet of trains with identical features and components, allows for

substantial savings in parts inventory and other economies of scale. In particular, commonality of rolling stock and other equipment will standardize maintenance training, enhance efficiencies and foster broad expertise in train and system repair.

The MWRRS study developed a cost of $9.87 per train mile for a 300-seat train in $2002. This cost was increased to $12.70 per train mile in $2013. Available evidence suggests that the maintenance cost for a conventional electric train should be about 9 percent cheaper per equivalent seat-mile than that of a diesel train leading to a unit cost of $11.27 per mile for a 150-mph locomotive hauled electric train. However, high speed electric trains have a more than proportional increase in power: a typical 130-mph diesel train has about 18 kw/Seat; the 220-mph Alstom AGV has 24 kw/Seat[10] while the 160-mph Acela is rated at 30kw/Seat. However, the Acela needs this much power due to the high weight of the steel coaches and low seating capacity of the train. As a result, the maintenance cost per mile for the 220-mph electric train benchmarked only slightly higher than that for the 130-mph diesel of equivalent capacity; a cost of $14.08 per mile was assumed for the 220-mph electric train. The 79-mph conventional Amtrak train benchmarked at a higher cost of $15.43 due primarily to a lack of economies of scale associated with typical lighter density Amtrak corridors.

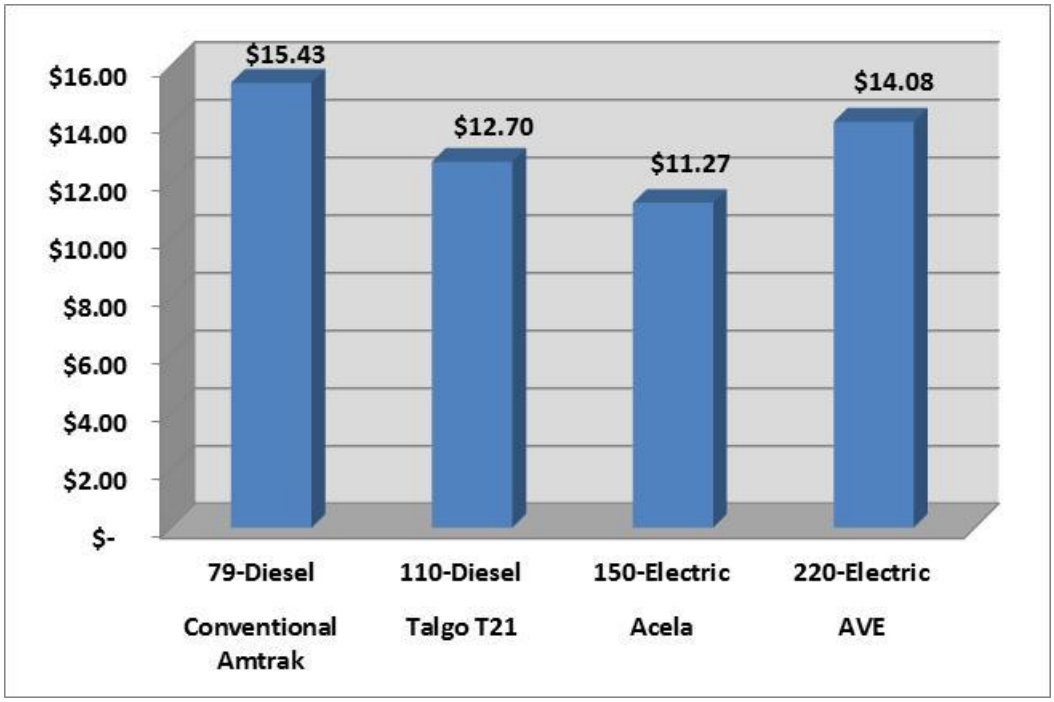
For this study:

- A $15.43 cost will be assumed for low frequency 79-mph options. These are characteristic of the current Amtrak service to Norfolk and Newport News, but were not part of any options assessed in this study.
- The intermediate $12.70 cost will be assumed for the 130-mph diesel options.
- A lower $11.27 level of cost would be assumed for electric trains running at 150 mph maximum. As a result, the extra power and traction motors are not needed, so the lower maintenance cost could be assumed. However, these trains were not used in any options assessed in this study.
- The highest $14.08 cost will be used for the 220-mph electric train operating on a Greenfield.

These costs are summarized in Exhibit 5-19.

[10] See: http://en.wikipedia.org/wiki/Automotrice_%C3%A0_grande_vitesse

Exhibit 5-19: Equipment Maintenance Cost per Mile ($2013)



TRAIN AND ENGINE CREW COSTS

The train operating crew incurs crew costs. Following Amtrak staffing policies, the operating crew would consist of an engineer, a conductor and an assistant conductor and is subject to federal Hours of Service regulations. Costs for the crew include salary, fringe benefits, training, overtime and additional pay for split shifts and high mileage runs. An overtime allowance is included as well as scheduled time-off, unscheduled absences and time required for operating, safety and passenger handling training. Fringe benefits include health and welfare, FICA and pensions. The cost of employee injury claims under FELA is also treated as a fringe benefit for this analysis. The overall fringe benefit rate was calculated as 55 percent. In addition, an allowance was built in for spare/reserve crews on the extra board. Costing of train crews was based on Amtrak's 1999 labor agreement, adjusted for inflation to 2013.

Crew costs depend upon the level of train crew utilization, which is largely influenced by the structure of crew bases and any prior agreements on staffing locations. Train frequency strongly influences the amount of held-away-from-home-terminal time, which occurs if train crews have to stay overnight in a hotel away from their home base. Since a broad range of service frequencies and speeds have been evaluated here, a parametric approach was needed to develop a system average per train mile rate for crew costs. Such an average rate necessarily involves some approximation, but to avoid having to reconfigure a detailed crew-staffing plan whenever the train schedules change, an average rate is appropriate for the current feasibility level study. A more specific and detailed level of assessment would be appropriate for a Tier 2 EIS. For this study:

- An intermediate value of $4.92 per train mile was assumed for the high frequency 130-mph diesel options. This is a moderate level of crew cost that includes the need for some away-from-home layover.
- 79-mph service would cost $6.59 per train-mile because of poor crew utilization in these very low-frequency scenarios. With trains operating less frequently there is less opportunity to return

crews to their home base on the same day, leading to more split shifts and overnight layovers. However, these trains were not part of any options assessed in this study.

- The 220-mph Greenfield scenario used $4.60 per train mile, reflecting operating efficiencies related both to higher speeds and more frequent trains in this scenario only, both of which tend to reduce the need for away-from-home layovers.

FUEL AND ENERGY

An average consumption rate of 2.42 gallons/mile was estimated for a 110-mph 300-seat train, based upon nominal usage rates of all three technologies considered in Phase 3 of the MWRRS Study. Assuming $3.60 a gallon in late 2013 for diesel fuel according to Energy Information Administration (EIA)[11], this translates into a cost of $8.71 per train mile, more than tripling (375%) the cost of diesel fuel that was prevalent at the time of the earlier MWRRS study. During the same time period however, electricity costs did not rise nearly so much. For example, Virginia electric power costs rose only by 46%.

However, electric traction has an advantage over diesel since it can be powered from any energy source, not just petroleum-based fuel. Even taking typical peaking demands into account, electricity is typically cheaper than diesel fuel. As a result, the rapid rise of petroleum costs over the past ten years has tipped the cost advantage towards electrification.

However, there is a large regional variation in electricity and peak usage rate structures. For example, electric power has in the past been more expensive than diesel traction in the northeastern United States. But the southeast enjoys lower average electricity rates than do northeastern states:[12] in 2010, for example, Virginia electric power for transportation averaged only 7.7¢ per kWH as compared to 11.9¢ per kWH in New Jersey. The actual price paid is also driven by the peak hour surcharges that can more than double a railroad's electric energy bill.

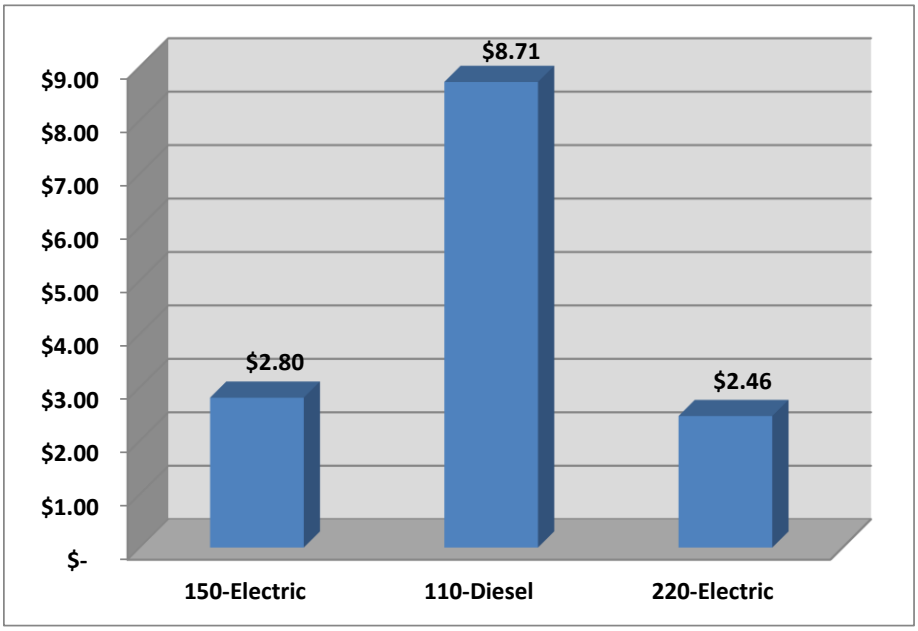
However, by employing power smoothing techniques such as onboard and wayside energy storage, as well as by regenerating electric power while braking, the rail operator might reduce the level of fluctuation in its energy usage so it pays closer to the base average kilowatt-hour power generation charge. Given the high cost associated with electric power purchases, the issue of demand smoothing is an issue that should receive careful attention in the train equipment procurement, as well as in the design of the electric traction system. The structure of peak usage charges should be negotiated with the electric utilities to ensure that the operator can purchase the power it needs at the lowest possible cost.

As shown in Exhibit 5-20, and including the Peak Usage charge, the comparable electric cost for an Acela 150-mph locomotive-hauled electric train is just $2.80 per train mile as compared to $8.71 for the diesel 130-mph train. But because it weighs less than the Acela, the 220-mph electric multiple unit is even more efficient at $2.46 per train mile. Also, the 220-mph electric train on a greenfield needs to accelerate and brake less than a train operating over an existing rail or highway alignments would. This results in a more uniform electric load which should lead to a more favorable utility rate negotiation.

On the other hand, the 220-mph electric train does go faster. This speed increases its energy consumption, largely offsetting the weight improvement. As a result, all diesel options assume a 2013 fuel cost of $8.71 per train mile, and all electric options assume an electric cost of $2.80 per train mile. These energy costs are then adjusted each year in line with the relevant Energy Information Administration forecasts.

[11] EIA diesel retail price in 2013 excluding the taxes http://www.eia.gov/petroleum/gasdiesel/
[12] See http://www.eia.gov/electricity/state/

Exhibit 5-20: Fuel and Energy Cost per Mile ($2013)



ONBOARD SERVICES (OBS)

Onboard service (OBS) costs are those expenses for providing food service onboard the trains. OBS adds costs in three different areas: equipment, labor and cost of goods sold. Equipment capital and operating cost is built into the cost of the trains and is not attributed to food catering specifically. Small 200-seat trains cannot afford a dedicated dining or bistro car. Instead, an OBS employee or food service vendor would move through the train with a trolley cart, offering food and beverages for sale to the passengers.

The goal of OBS franchising should be to ensure a reasonable profit for the provider of on-board services, while maintaining a reasonable and affordable price structure for passengers. In previous studies, it has been found that the key to attaining OBS profitability is selling enough products to recover the train mile related labor costs. For example, if small 200-seat trains were used, given the assumed OBS cost structure, even with a trolley cart service the OBS operator will be challenged to attain profitability. However, the expanded customer base on larger 300-seat trains can provide a slight positive operating margin for OBS service. 400-seat electric trains should usually provide a comfortable positive profit margin for the OBS operator.

Because the trolley cart has been shown to double OBS revenues, it can result in profitable OBS operations in situations where a bistro-only service would be hard-pressed to sell enough food to recover its costs. While only a limited menu can be offered from a cart, the ready availability of food and beverages at the customer's seat is a proven strategy for increasing sales. Many customers appreciate the convenience of a trolley cart service and are willing to purchase food items that are brought directly to them. While some customers prefer stretching their legs and walking to a bistro car, other customers will not bother to make the trip.

The cost of goods sold is estimated as 50 percent of OBS revenue, based on Amtrak's route profitability reports. Labor costs, including costs for commissary support and OBS supervision, have been estimated at:

- An intermediate value of $2.56 per train mile was assumed for the 130-mph diesel options. This is a moderate level of crew cost that includes the need for some away-from-home layover.

- Existing rail 79-mph scenarios would cost $3.66 per train-mile because of poor crew utilization in these very low-frequency scenarios. With trains operating less frequently there is less opportunity to return crews to their home base on the same day, leading to more split shifts and overnight layovers. However, these trains were not part of any options assessed in this study.
- The 220-mph Greenfield scenario used $2.41 per train mile, reflecting operating efficiencies related both to higher speeds and more frequent trains in this scenario only, both of which tend to reduce the need for away-from-home layovers.

These costs are generally consistent with Amtrak's level of wages and staffing approach for conventional bistro car services. However, this Business Plan recommends that an experienced food service vendor provide food services and use a trolley cart approach. A key technical requirement for providing trolley service is to ensure the doors and vestibules between cars are designed to allow a cart to easily pass through. Since trolley service is a standard feature on most European railways, most European rolling stock is designed to accommodate the carts. Although convenient passageways often have not been provided on U.S. equipment, the ability to support trolley carts is an important equipment design requirement for the planned service.

INSURANCE COSTS

Liability costs were estimated at 1.4¢ per passenger-mile, the same rate that was assumed in the earlier MWRRS study brought to $2013. Federal Employees Liability Act (FELA) costs are not included in this category but are applied as an overhead to labor costs.

The Amtrak Reform and Accountability Act of 1997 (§161) provides for a limit of $200 million on passenger liability claims. Amtrak carries that level of excess liability insurance, which allows Amtrak to fully indemnify the freight railroads in the event of a rail accident. This insurance protection has been a key element in Amtrak's ability to secure freight railroad cooperation. In addition, freight railroads perceive that the full faith and credit of the United States Government is behind Amtrak, while this may not be true of other potential passenger operators. However, a General Accounting Office (GAO) review13 has concluded that this $200 million liability cap applies to commuter railroads as well as to Amtrak. If the GAO's interpretation is correct, the liability cap may also apply to potential franchisees. If this limitation were in fact available to potential franchisees, it would be much easier for any operator to obtain insurance that could fully indemnify a freight railroad at a reasonable cost. It is recommended that Virginia DOT seek qualified legal advice on this matter.

5.4 FIXED ROUTE COSTS

This cost category includes those costs that, while largely independent of the number of train-miles operated, can still be directly associated to the operation of specific routes. It includes such costs as track maintenance, which varies by train technology, and station operations.

TRACK AND RIGHT-OF-WAY COSTS

Currently, it is industry practice for passenger train operators providing service on freight-owned rights-of-way to pay for track access, dispatching and track maintenance. Rates for all these activities are ultimately based upon a determination of the appropriate costs that result from negotiations between the parties. The purpose here is to provide estimates based on the best available information; however, as the project moves forward, additional study and discussions with the railroads will be needed to further refine these costs.

[13] See: http://www.gao.gov/highlights/d04240high.pdf

To accommodate passenger trains, the Norfolk Southern existing rail corridor would need a substantial increase in capacity or else a new Greenfield alignment would need to be constructed. Once built, these improvements would need to be maintained to FRA standards required for reliable and safe operations. The costing basis assumed in this report is that of incremental or avoidable costs[14] for shared tracks. The passenger operator, however, must take full cost responsibility for maintaining any tracks that it must add to the corridor either for its own use, or for mitigating delays to freight trains. The following cost components are included within the Track and Right-of-Way category:

- **Track Maintenance Costs**. Costs for track maintenance were estimated based on Zeta-Tech's January 2004 draft technical monograph Estimating Maintenance Costs for Mixed High-Speed Passenger and Freight Rail Corridors.[15] Zeta-Tech costs have been adjusted for inflation to $2013. However, Zeta-Tech's costs are conceptual and subject to negotiation with the freight railroads.
- **Dispatching Costs and Out-of-Pocket Reimbursement.** Passenger service must also reimburse a freight railroad's added costs for dispatching its line, providing employee efficiency tests and for performing other services on behalf of the passenger operator. If the passenger operator does not contract a freight railroad to provide these services, it must provide them itself. As a result, costs for train dispatching and control are incurred on dedicated as well as shared tracks and are now shown under a separate "Operations and Dispatch" cost category.
- **Costs for Access to Track and Right-of-Way**. Access fees, particularly train mile fees incurred as an operating expense, are specifically excluded from this calculation. Any such payments would have to be calculated and negotiated on a route-specific and railroad-specific basis. Such a calculation would have to consider the value of the infrastructure improvements made to the corridor for balancing up-front capital with ongoing operating payments.[16]

Exhibit 5-21 shows the conceptual relationship between track maintenance cost and total tonnage that was calibrated from the 2004 Zeta-Tech study. It shows a strong relationship between tonnage, FRA track class (4 through 6, corresponding to a 79-mph to 110-mph track speed) and maintenance cost. At low tonnage, the cost differential for maintaining a higher track class is not very large, but as tonnage grows, so too does the added cost. For shared track, if freight needs only Class 4 track, the passenger service would have to pay the difference, called the "maintenance increment", which for a 25 MGT line as shown in Exhibit 5-21, would come to about $22,000 per mile per year (in $2002), including capital costs[17]. The required payment to reimburse a freight railroad for its added cost would be less for lower freight tonnage, more for higher freight tonnage.

Exhibit 5-21 also breaks out the operating versus total track maintenance cost, showing that capital (the difference between total and operating cost) is a significant share of the total cost. For track maintenance:

[14] Avoidable costs are those that are eliminated or saved if an activity is discontinued. The term incremental is used to reference the change in costs that results from a management action that increases volume, whereas avoidable defines the change in costs that results from a management action that reduces volume.

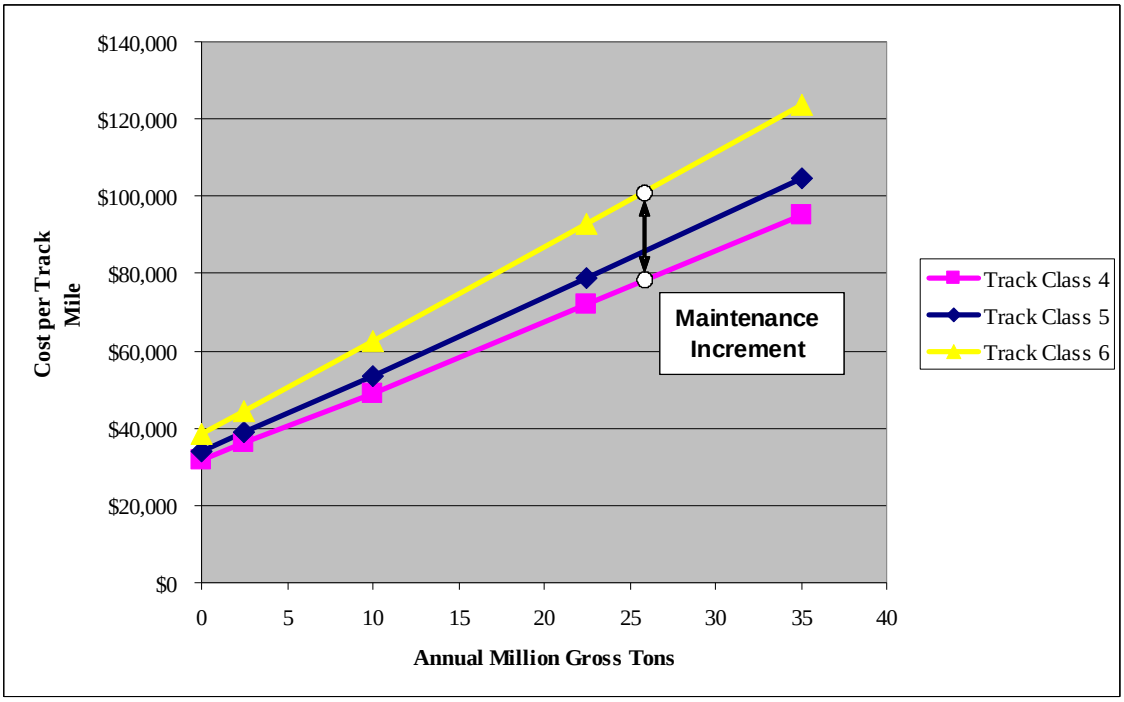
[15] Zeta-Tech, a subsidiary of Harsco (a supplier of track maintenance machinery) is a rail consulting firm who specializes in development of track maintenance strategies, costs and related engineering economics. See a summary of this report at http://onlinepubs.trb.org/onlinepubs/trnews/trnews255rpo.pdf. The full report is available upon request from the FRA.

[16] For 110-mph service, the level of infrastructure improvements to the corridor called for in this study should provide enough capacity to allow superior on-time performance for both freight and passenger operations

[17] Calculated as $38,446 - $31,887 + ($2.440 – $1.810) * 25 = $22,309 per year. Note that the yellow highlighted cells in the table correspond to the three lines shown on the graph.

- ***Operating costs*** cover expenses needed to keep existing assets in service and include both surfacing and a regimen of facility inspections.
- ***Capital costs*** are those related to the physical replacement of the assets that wear out. They include expenditures such as for replacement of rail and ties, but these costs are not incurred until many years after construction. In addition, the regular maintenance of a smooth surface by reducing dynamic loads actually helps extend the life of the underlying rail and tie assets.

Exhibit 5-21: Zeta-Tech 2004 Calibrated Track Class vs. Tonnage Total Cost Function ("Middle Line" Case, in $2002)



TOTAL	LOW		MIDDLE		HIGH	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
Class 3[1]	$17,880	$0.917	$21,683	$1.231	$25,487	$1.548
Class 4	$26,294	$1.348	$31,887	$1.810	$37,481	$2.277
Class 5	$28,072	$1.509	$33,937	$2.020	$39,801	$2.530
Class 6	$31,714	$1.837	$38,446	$2.440	$45,178	$3.035

OPER	LOW		MIDDLE		HIGH	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
Class 3	$6,558	$0.579	$8,216	$0.726	$9,873	$0.872
Class 4	$9,644	$0.852	$12,082	$1.067	$14,519	$1.283
Class 5	$11,283	$0.997	$14,135	$1.249	$16,987	$1.501
Class 6	$14,640	$1.293	$18,371	$1.623	$22,101	$1.953

Exhibit 5-21 shows that the cost of shared track depends strongly on the level of freight tonnage, since passenger trains are relatively lightweight and do not contribute much to the total tonnage. In fact, following the Zeta-Tech methodology, the "maintenance increment" is calculated based on freight tonnage only, since a flat rate of $1.56 per train mile as used in the Zeta- Tech report (in $2002) was already added to reflect the direct cost of added passenger tonnage regardless of track class. This cost, which was developed by Zeta-Tech's TrackShare® model, includes not only directly variable costs, but also an allocation of a freight railroad's fixed cost. Accordingly, it complies with the Surface Transportation Board's definition of "avoidable cost." Inflated to $2013 (an approximate 52% increase, a higher rate of inflation than CPI, reflecting the energy-intensity of construction materials) this avoidable cost allocation would come to $2.37 per train mile. It should be noted that Norfolk Southern policy does not allow for upgrading shared freight tracks above 79-mph. Accordingly, this $2.37 per train mile is the rate that would be assumed for shared use of Norfolk Southern freight tracks. The "maintenance increment" as described earlier is not relevant to this case since it is assumed that the tracks are not upgraded beyond what are needed for freight use.

On top of this, an allowance of 39.5¢ per train-mile (in $2002) was added by Zeta-Tech for freight railroad dispatching and out-of-pocket costs. Inflated to $2013 based on the Consumer Price Index (approx. 29% increase) this dispatching and out-of-pocket cost now comes to 50.8¢ per train mile, which is applied both to dedicated and shared tracks. This cost is now separated from track maintenance under the "Operations and Dispatch" category.

The same cost function shown in Exhibit 5-21 can also be used for costing dedicated passenger track. With dedicated track, the passenger system is assumed to cover the entire operating cost for maintaining its own track. (Freight may then have to reimburse the passenger operator on a car-mile basis for any damage it causes to the passenger track.) Because passenger train tonnage is very low however, it can be seen that the cost differential between Class 4, 5 and 6 track is very small. Adjusting Zeta-Tech's $2002 costs shown in Exhibit 5-21 up to $2013:

- The Total cost per track-mile for maintaining dedicated Class 4 track is about $48,468; the cost for Class 6 track rises to $58,438. For a shared-use scenario, this assumes that Norfolk Southern would require this level of support each year for maintaining the additional tracks that it must add to its existing rail corridor, for supporting the needs of passenger rail service.
- The Operating cost per track-mile for maintaining dedicated Class 4 track is about $18,365; the cost for Class 6 track rises to $27,924.
- The Capital cost per track-mile for maintaining dedicated Class 4 track reflects the difference of about $30,103; similarly for Class 6 track is $30,514. The capital cost for maintaining Class 4 versus Class 6 track under light tonnage density is not much different; most of cost differential is in operating cost needed to maintain the more precise alignment of the higher class track.
- Adding $26,859 per track-mile for overhead electric catenary, the overall operating maintenance cost for electrified dedicated track rises to $27,924 + $26,859 = $54,783 per track mile per year. We do not account for separate capital cost replacement for catenary, since the $26,859 per track-mile estimate accounts for both operating and normalized capital power system maintenance.

Reducing axle loads as is a common design practice for 220-mph high speed equipment. This helps keep guideway maintenance costs low and in line with the above assumed costs. French experience[18] showed

[18] See Maintenance Costs of High-Speed Lines in Europe: State of the Art, Transportation Research Record, Railways 2008: http://trb.metapress.com/content/gg76453p458327qr/?genre=article&id=doi%3a10.3141%2f2043-02

that the maintenance cost of a dedicated high speed track was actually lower (just 55%) of the cost of a conventional track with equivalent traffic. According to the French railways, the justification for such a difference was due basically to three causes: the uniformity of TGV rolling stock, the reduced axle loading (17 metric tons) and the strict quality conditions imposed during the construction of the line. Table 6 of this same report showed that the mixture of traffic operated over a line influences track maintenance cost much more than does the top speed. This finding is consistent with United States experience as shown in Exhibit 5-21. As a result, considering the maintenance of a 220-mph dedicated track costs as equivalent to that of a Class 6 line shared with freight trains is, if anything, conservative.

While operating costs are needed every year, capital maintenance costs for dedicated tracks are gradually introduced using a table of ramp-up factors provided by Zeta-Tech, see Exhibit 5-22.

Exhibit 5-22: Capital Cost Ramp-Up Following Upgrade of a Rail Line

Year	% of Capital Maintenance	Year	% of Capital Maintenance
0	0%	11	50%
1	0%	12	50%
2	0%	13	50%
3	0%	14	50%
4	20%	15	75%
5	20%	16	75%
6	20%	17	75%
7	35%	18	75%
8	35%	19	75%
9	35%	20	100%
10	50%		

A fully normalized capital maintenance level is not reached until 20 years after completion of the rail construction program. This is used for calculating "Cyclic Maintenance" in the Benefit Cost Analysis. But because Cyclic Maintenance is not an Operating Cost under GAAP accounting methodology, it is not normally included in the Operating Ratio calculation.

STATION OPERATIONS

A simplified fare structure, heavy reliance upon electronic ticketing and avoidance of a reservation system will minimize station personnel requirements. Station costs include personnel, ticket machines and station operating expenses.

- Staffed stations will be assumed at major stations. All stations will be assumed open for two shifts. The cost for the staffed stations includes eight positions at each new location, costing $644,640 per year, as well as the cost of utilities, ticket machines, cleaning and basic facility maintenance.
- The cost for unstaffed stations covers the cost of utilities, ticket machines, cleaning and basic facility maintenance, costing $80,580 per year. (These costs are also included in the staffed station cost.) Volunteer personnel such as Traveler's Aid, if desired could staff these stations.

Costing of the Richmond Direct option assumes 9 staffed stations, and the Petersburg/Hopewell option is based on 10 staffed stations.

5.5 SYSTEM OVERHEAD COSTS

The category of System Overhead largely consists of Service Administration or management overheads, covering such needs as the corporate procurement, human resources, accounting, finance and information technology functions as well as call center administration. A stand-alone administrative

organization appropriate for the operation of a corridor system was developed for the MWRRS and later refined for the Ohio Hub studies. This organizational structure, which was developed with Amtrak's input and had a fixed cost of $8.9 million plus $1.43 per train-mile (in $2002) for added staff requirements as the system grew. Inflated to $2013, this became $11.45 million plus $1.84 per train mile. However, the Sales and Marketing category also has a substantial fixed cost component for advertising and call center expense, adding another $2.9 million per year fixed cost, plus variable call center expenses of 70.9¢ per rider, all in $2013.[19] Finally, credit card (1.8% of revenue) and travel agency commissions (1%) are all variable.

Therefore, the overall financial model for a Stand-alone organization therefore has $14.35 million ($11.45 + $2.9 million) annually in fixed cost for administrative, sales and marketing expenses. In addition, the system operator was allowed a 10 percent markup on certain direct costs as an allowance for operator profit.

5.6 RESULTS/TABLES

Exhibit 5-23 summarizes the Unit Cost factors used for developing Operating costs for each alternative. Following the original MWRRS methodology, those costs marked with an asterisk (*) are subject to the 10% Operator Profit markup.

[19] In the MWRRS cost model, call center costs were built up directly from ridership, assuming 40 percent of all riders call for information, and that the average information call will take 5 minutes for each round trip. Call center costs, therefore, are variable by rider and not by train-mile. Assuming some flexibility for assigning personnel to accommodate peaks in volume and a 20 percent staffing contingency, variable costs came to 57¢ per rider. These were inflated to 66¢ per rider in $2008 and now 70.9¢ per rider in $2013.

Exhibit 5-23: Unit Operating and Maintenance Costs

Unit Cost	Driver	Shared 79-mph diesel	Shared 110-mph diesel	Greenfield 130-mph diesel	Greenfield 220-mph electric
Equipment Maintenance	Train-Miles	$15.43	$15.43	$12.70	$14.08
Train Crew *	Train-Miles	$6.59	$6.59	$4.92	$4.60
Fuel or Energy *	Train-Miles	$8.71	$8.71	$8.71	$2.80
On Board Services (Labor) *	Train-Miles	$3.66	$3.66	$2.56	$2.41
On Board Services (Goods Sold) *	% of OBS Revenue	50%	50%	50%	50%
Insurance	Passenger-Mile	1.4¢	1.4¢	1.4¢	1.4¢
Track (Shared)	Train-Miles over Shared Track	$2.37	$2.37	N/A	N/A
Track and Electrification (Dedicated)	Dedicated Track Miles	$48,468	$58,438	$27,924 plus Cyclic Capital	$54,783 plus Cyclic Capital
Operations and Dispatch *	Train-Miles	50.8¢	50.8¢	50.8¢	50.8¢
Stations * - Staffed	Per Station	$644,640	$644,640	$644,640	$644,640
Stations* - Unstaffed	Per Station	$80,580	$80,580	$80,580	$80,580
Administration and Management (Fixed) *	Fixed	$14.35 mill	$14.35 mill	$14.35 mill	$14.35 mill
Administration and Management (Variable Train-Mile) *	Train-Miles	$1.84	$1.84	$1.84	$1.84
Administration and Management (Call Center: Variable Riders) *	Riders	70.9¢	70.9¢	70.9¢	70.9¢
Credit Card and Travel Agency Commissions *	Percent of Revenue	2.8%	2.8%	2.8%	2.8%
Operator Profit Markup	Selected (*) Costs	10%	10%	10%	10%

Exhibit 5-24 shows the Operating Costs for each rail route and speed option. It can be seen that each of the 130 mph options cost between $150-155 million in 2035 while the 220-mph options cost around $200 million in the same year. As a result it can be seen that the 220-mph options only cost an extra $50 million per year despite operating more train miles as a result of the increased frequency offered at higher speed. However, Option 4 costs an addition $65 million which reflects the cost of the additional trains to Newport News which are added under that option.

Exhibit 5-24: 2035 Operating and Maintenance Costs Results

Financial 2035 (mill. 2013$)	Southern Option 1 Via Petersburg				Northern Option 2 -Via Hopewell				Option 3 Richmond Direct		Option 4 Richmond Direct Improved
	Southern Option 1A Greenfield		Southern Option 1B Norfolk Southern		Northern Option 2A Greenfield		Northern Option 2B Norfolk Southern				
	130mph	220mph	130mph	220mph	130mph	220mph	130mph	220mph	130mph	220mph	220mph
Train Crew	$12.85	$18.16	$12.85	$18.16	$12.70	$17.78	$12.70	$17.78	$13.05	$18.19	$24.71
OBS	$16.04	$25.01	$16.04	$25.01	$15.77	$24.50	$15.77	$24.50	$16.44	$25.18	$36.97
Equipment	$33.16	$55.58	$33.16	$55.58	$32.78	$54.43	$32.78	$54.43	$33.69	$55.67	$75.64
Fuel	$24.36	$10.66	$24.36	$10.66	$24.08	$10.44	$24.08	$10.44	$24.75	$10.67	$14.51
Track	$11.95	$23.45	$11.95	$23.45	$11.78	$23.12	$11.78	$23.12	$11.56	$22.68	$25.47
Insurance	$8.77	$13.26	$8.77	$13.26	$8.67	$12.99	$8.67	$12.99	$8.91	$13.28	$18.05
Call Ctr Variable	$3.13	$4.43	$3.13	$4.43	$3.09	$4.33	$3.09	$4.33	$3.26	$4.58	$6.16
T-Agent and CC Comm	$6.55	$10.85	$6.55	$10.85	$6.42	$10.63	$6.42	$10.63	$6.75	$10.96	$16.81
Stations	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$5.91	$5.91	$6.98
Admin and Mgt	$19.15	$21.61	$19.15	$21.61	$19.10	$21.46	$19.10	$21.46	$19.23	$21.62	$24.24
Operation & Dispatch	$1.09	$1.70	$1.09	$1.70	$1.07	$1.67	$1.07	$1.67	$1.05	$1.64	$2.61
Operator Profit 10% selected items	$8.96	$9.89	$8.96	$9.89	$8.87	$9.73	$8.87	$9.73	$9.05	$9.87	$13.30
Total Cost	**$152.46**	**$201.03**	**$152.46**	**$201.03**	**$150.78**	**$197.52**	**$150.78**	**$197.52**	**$153.66**	**$200.25**	**$265.45**

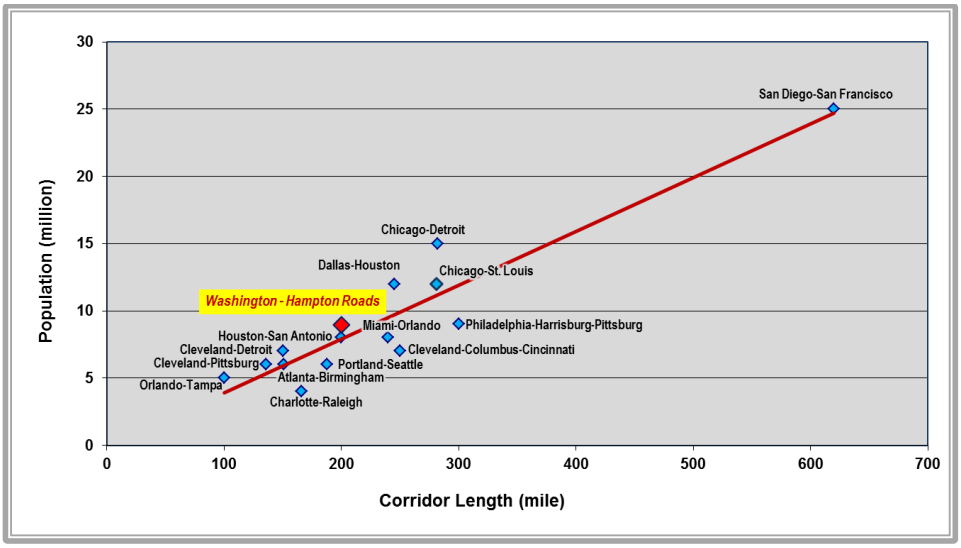
6. MARKET ANALYSIS

The Market Analysis provides an assessment of the overall travel market and its comparison with other US high speed rail corridors. It describes the development of the very high quality travel demand model, its zones, and data sources used to develop forecasts. The socioeconomic growth projections and transport conditions for the corridor are also provided. A key input to the demand model was the Stated Preference Survey that estimated the responsiveness of the community to their travel options. Finally, the forecasts of ridership and revenue are described for each of the route and technology options.

6.1 OVERVIEW OF EXISTING TRAVEL MARKET

The Hampton Roads-Richmond-Washington Corridor is one of the top intercity corridors in the U.S., being comparable with California's San Francisco-San Diego, Florida's Miami-Orlando, Texas' Dallas-Houston Ohio's Cleveland-Columbus-Cincinnati, Pennsylvania's Philadelphia-Harrisburg-Pittsburgh, and Midwest's Chicago-St. Louis and Chicago-Detroit corridors; and is much stronger than many other corridors like Atlanta-Birmingham, Portland-Seattle, or Charlotte-Raleigh (Exhibit 6-1). As such, the corridor has independent utility as a high-speed corridor

Exhibit 6-1: Corridor Comparison



In addition to this corridor having independent utility in its own right, it should be recognized that is really the southern extension of the Northeast corridor and a logical part of the "East Coast Mega Region" that stretches from Boston to New York to Philadelphia to Washington and on to Richmond and Hampton Roads. The impact of being linked to this Mega Region is to effectively double the volume of trips that the corridor would have as a freestanding corridor, and thus significantly enhances its potential for High Speed and Enhanced Intercity Passenger Rail.

Like many intercity passenger rail corridors the demand for travel in the corridor is strong. In 2012 the Hampton Roads – Richmond - Washington Corridor had a population of nearly ten million. The corridor also hosts large number of finance and business services, research and high-tech industry, government agencies and military bases. In 2012 the total employment in the corridor was over six million and per capita income was $39,648. Projections indicate that the corridor's demographic and economic growth will continue over the next several decades, the population is projected to be over 12 million in 2040, employment will be 8.5 million in 2040, and per capita incomes will grow to $53,227 in 2040 in 2012

dollars. As a result, the Hampton Roads – Richmond – Washington Corridor has a high level of business and commuter travel between its urban areas together with significant social and tourist travel. The total annual intercity one-way trips in the corridor is estimated to be 59 million in 2012. This means the average resident takes 6.6 one way or 3.3 round intercity trips per year.

6.2 BASIC STRUCTURE OF THE COMPASS™ TRAVEL MARKET FORECAST MODEL

For the purpose of this study, the ridership and revenue forecast will be produced using the COMPASS™ Travel Demand Model. The COMPASS™ Multimodal Demand Forecasting Model is a flexible demand forecasting tool used to compare and evaluate alternative passenger rail network and service scenarios. It is particularly useful in assessing the introduction or expansion of public transportation modes such as air, bus or high speed rail into markets. Exhibit 6-2 and 6-3 show the structure and working process of the COMPASS™ Model. As shown, the inputs to the COMPASS™ Model are base and proposed transportation networks, base and projected socioeconomic data, value of time and value of frequency from Stated Preference surveys, and base year travel data obtained from government agencies and transportation service operators.

The COMPASS™ Model structure incorporates two principal models: a Total Demand Model and a Hierarchical Modal Split Model. These two models are calibrated separately. In each case, the models are calibrated for origin-destination trip making in the study area. The Total Demand Model provides a mechanism for replicating and forecasting the total travel market. The total number of trips between any two zones for all modes of travel is a function of (1) the socioeconomic characteristics of the two zones and (2) the travel opportunities provided by the overall transportation system that exists (or will exist) between the two zones. Typical socioeconomic variables include population, employment and income. The quality of the transportation system is measured in terms of total travel time and travel cost by all modes, and the induced demand is estimated by considering the change in quality of travel offered by all modes.

The role of the COMPASS™ Modal Split Model is to estimate relative modal shares of travel given the estimation of the total market by the Total Demand Model. The relative modal shares are derived by comparing the relative levels of service (as estimated by generalized costs) offered by each of the travel modes. Four levels of binary choice were used in this study (see Exhibit 6-3). The first level separates two routes from Hampton Roads area to other areas in the corridor by rail. The second level separates rail services from bus services. The third level of the hierarchy separates air travel, the fastest and most expensive mode of travel, from surface modes of rail and bus services. The fourth level separates auto travel with its perceived spontaneous frequency, low access/egress times, and highly personalized characteristics, from public modes (i.e., air, rail and bus). The model forecasts changes in riders, revenue and market share based on changes travel time, frequency and cost for each mode as measured by the generalized costs for each mode. A more detailed description of the COMPASS™ Model is given in Appendix 2.

Exhibit 6-2: Structure of the COMPASS™ Model

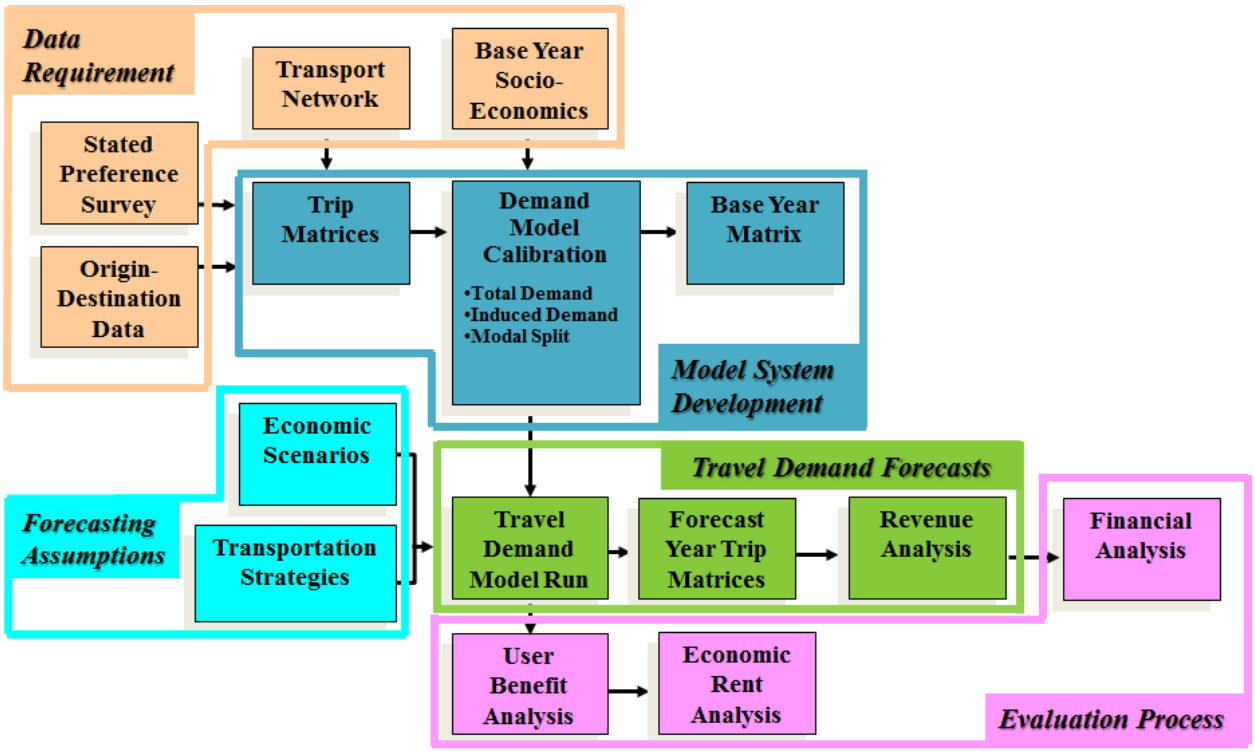
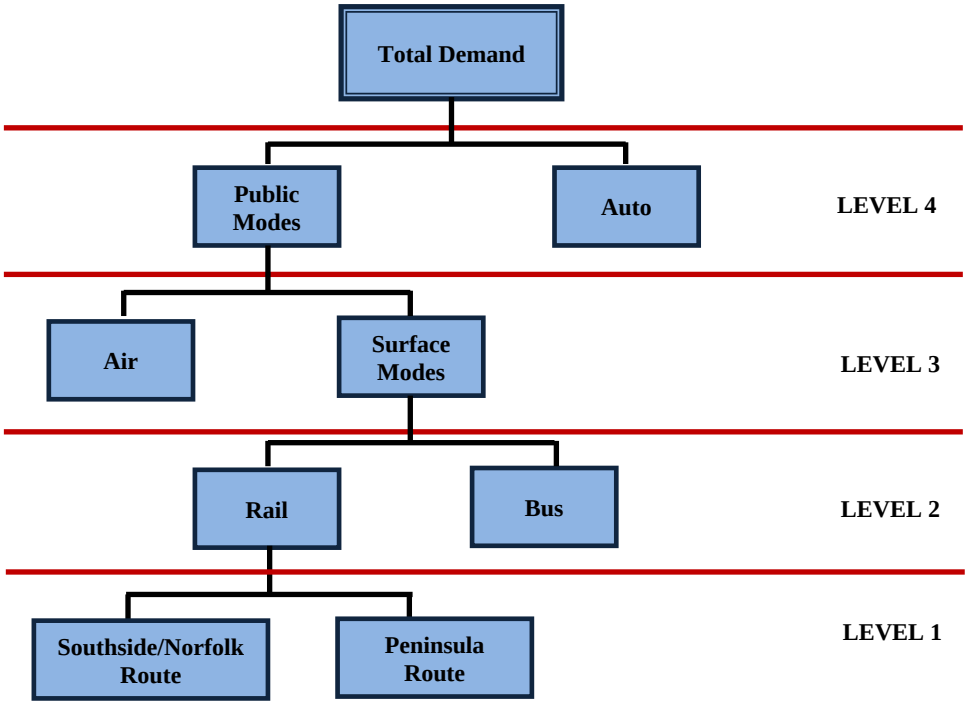


Exhibit 6-3: Hierarchical Structure of the Modal Split Model



A key element in evaluating passenger rail service is the comprehensive assessment of the travel market in the corridor under study, and how well the passenger rail service might perform in that market. For the purpose of this study, this assessment was accomplished using the following process:

- Building the zone system that enables more detailed analysis of the origin-destination travel market and the development of base year and future socioeconomic data for each zone.
- Compiling information on the service levels (times, fares, frequency, costs) in the corridor for auto, air, bus, and the proposed passenger rail travel.
- Identifying and quantifying factors that influence travel choices, including values of time, frequency and access/egress time.
- Developing strategies that quantify how travel conditions will change, including future gas price, future vehicle fuel efficiency improvement, and highway congestion.
- Developing and calibrating total travel demand and modal split models for travel demand forecasting.
- Forecasting travel, including total demand and modal shares.

The following sections document the modeling process and the forecasting results.

6.3 ZONE DEFINITION

The zone system provides a representation of the market areas among which travel occurs from origins to destinations. For intercity passenger rail planning, most rural zones can be represented by larger areas. However, where it is important to identify more refined trip origins and destinations in urban areas, finer zones are used. The travel demand model forecasts the total number of trip origins and destinations by mode and by zone pair. Because Hampton Roads – Richmond - Washington Corridor is closely related to the Northeast Corridor and Southeast Corridor, a zone system is needed that incorporates all areas that are part of the Northeast and Southeast corridors. To meet this need, a 333-zone system was developed for the whole study area based on aggregation of the 2010 census tracts and traffic analysis zones (TAZs) of local transportation planning agencies. Exhibit 6-4 shows the zone system for the whole study area. Exhibit 6-5 shows the zones in the Hampton Roads area.

Exhibit 6-4: Study Area Zone System

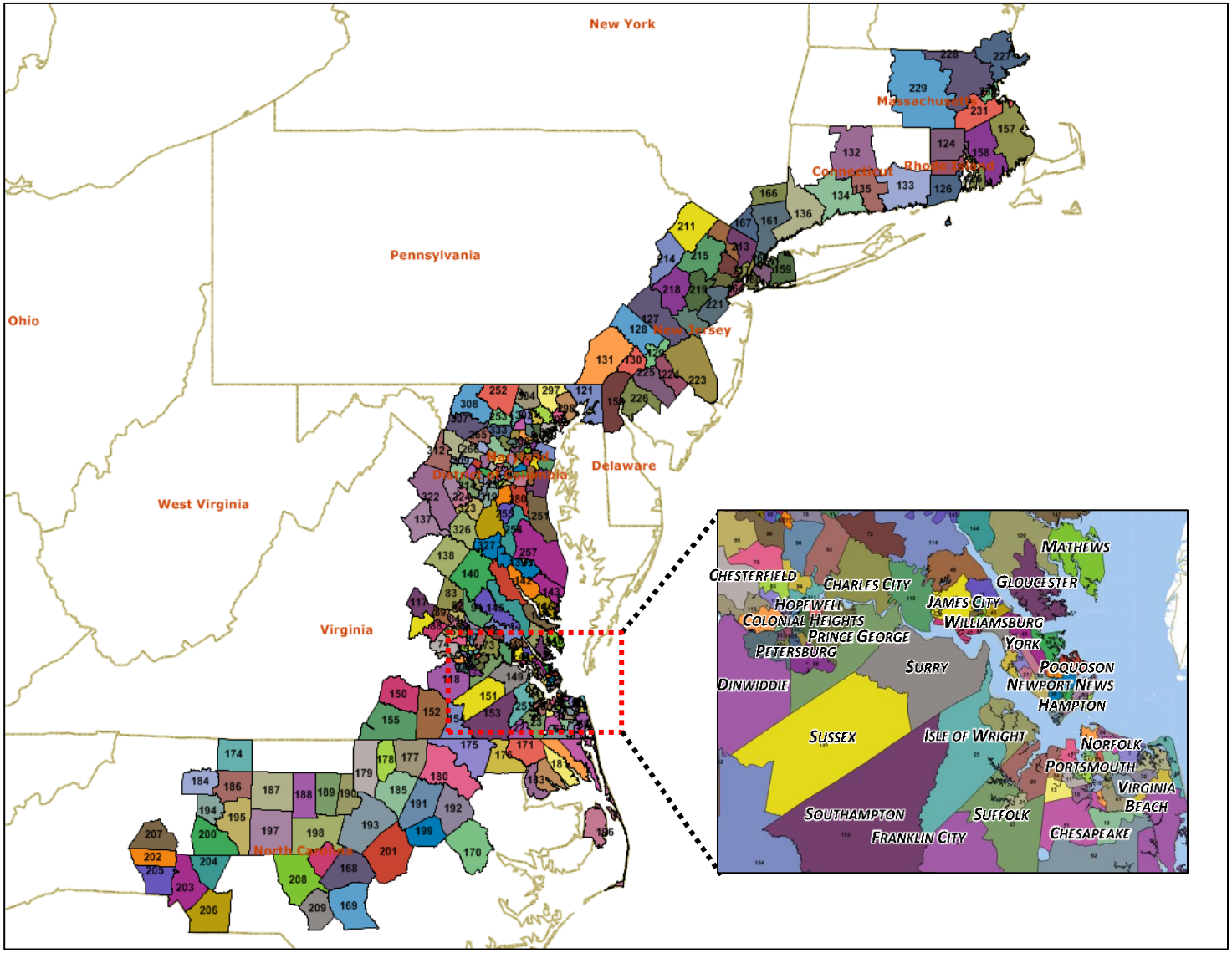


Exhibit 6-5: Hampton Roads Area Zones

6.4 SOCIOECONOMIC BASELINE AND PROJECTIONS

The travel demand forecasting model requires base year estimates and future growth forecasts of three socioeconomic variables of population, employment and per capita income for each of the zones in the study area. A socioeconomic database was established for the base year (2012) and for each of the forecast years (2015-2050). The data was developed at five-year intervals using the most recent data from the following sources:

- U.S. Census Bureau
- Hampton Roads Planning District Commission
- Richmond Regional Planning District Commission
- Crater Planning District Commission
- Virginia Employment Commission
- Metropolitan Washington County of Governments
- Baltimore Metropolitan Council
- Bureau of Economic Analysis
- Woods & Poole Economics, Inc.

Exhibit 6-6 shows the base year and projected socioeconomic data for the whole study area including Northeast and Southeast corridor regions. According to the data developed from these sources, the population will increase from 50.62 million in 2012 to 64.36 million in 2050, the total employment of the study area will increase from 30.99 million to 46.2 million in 2050, and per capita income will increase from $35,611 in 2012 to $52,304 in 2050 in 2012 dollars.

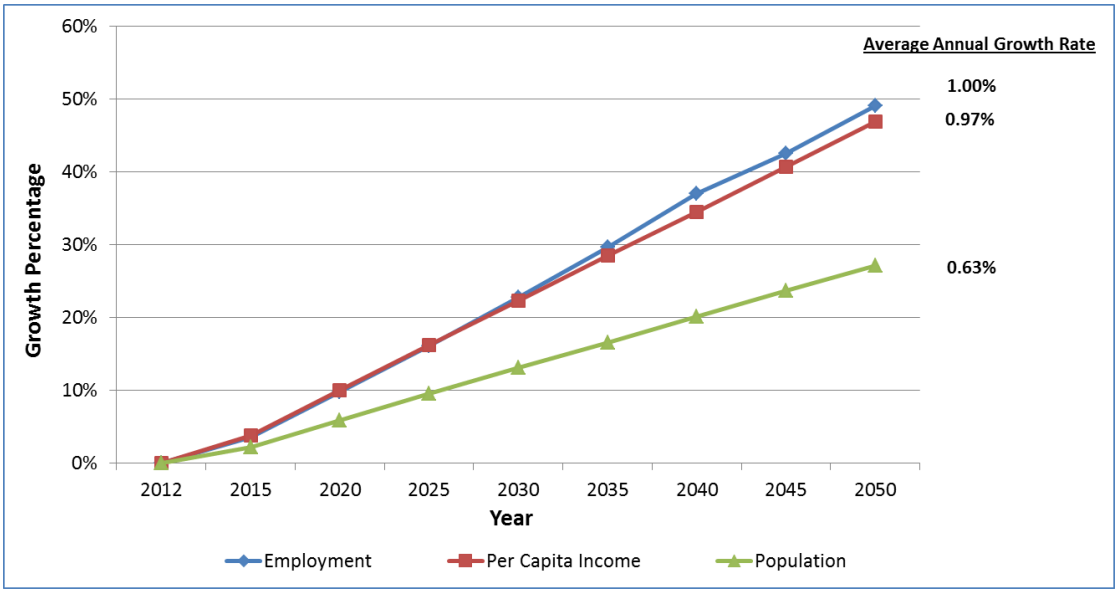
Exhibit 6-6: Base and Projected Socioeconomic Data for the Whole Study Area that Extends from Boston to Charlotte

Year	2012	2015	2020	2025	2030	2035	2040	2045	2050
Population	50,618,637	51,715,458	53,583,628	55,434,004	57,232,413	59,012,616	60,811,800	62,596,572	64,364,454
Employment	30,986,211	32,082,878	34,008,141	35,986,164	38,044,681	40,173,357	42,443,934	44,161,365	46,196,616
Per Capita Income (2012$)	35,611	36,957	39,176	41,378	43,567	45,745	47,889	50,120	52,304

Exhibit 6-7 shows the socioeconomic growth projections for the study area. The exhibit shows that there is higher growth of employment and income than population. Furthermore, travel increases are historically strongly correlated to increases in employment and income, in addition to changes in population. Therefore, travel in the corridor is likely to continue to increase faster than the population growth rates, as changes in employment and income outpace population growth, and stimulate more demand for traveling.

The exhibits in this section show the aggregate socioeconomic projection for the whole study area. It should be noted that in applying socioeconomic projections to the model, separate projections were made for each individual zone using the data from the listed sources. Therefore, the socioeconomic projections for different zones are likely to be different and thus may lead to different future travel sub-market projections. A full description of socioeconomic data of each zone can be found in the Appendix 1.

Exhibit 6-7: Socioeconomic Growth Projection for the Whole Study Area that extends from Boston to Charlotte



6.5 EXISTING TRAVEL MODES

In transportation analysis, travel desirability/utility is measured in terms of travel cost and travel time. These variables are incorporated into the basic transportation network elements that provide by mode the connections from any origin zone to any destination zone. Correct representation of the existing and proposed travel services is vital for accurate travel forecasting. Basic network elements are called nodes and links. Each travel mode consists of a database comprised of zones and stations that are represented by nodes, and existing connections or links between them in the study area. Each node and link is assigned a set of travel attributes (time and cost). The network data assembled for the study included the following attributes for all the zone pairs.

For public travel modes (air, rail, bus):

- Access/egress times and costs (e.g., travel time to a station, time/cost of parking, time walking from a station, etc.)
- Waiting at terminal and delay times
- In-vehicle travel times
- Number of interchanges and connection times
- Fares
- Frequency of service

For private mode (auto):

- Travel time, including rest time
- Travel cost (vehicle operating cost)
- Tolls
- Parking Cost
- Vehicle occupancy

The transportation travel attribute or service data of different modes available in the study corridor were obtained from a variety of sources and coded into the COMPASS™ networks as inputs to the demand model. The major sources are as follows.

The highway network was developed to reflect the major highway segments within the study area. The sources for building the highway network in the study area are as follows:

- State and Local Departments of Transportation highway databases
- National Highway System (NHS) database

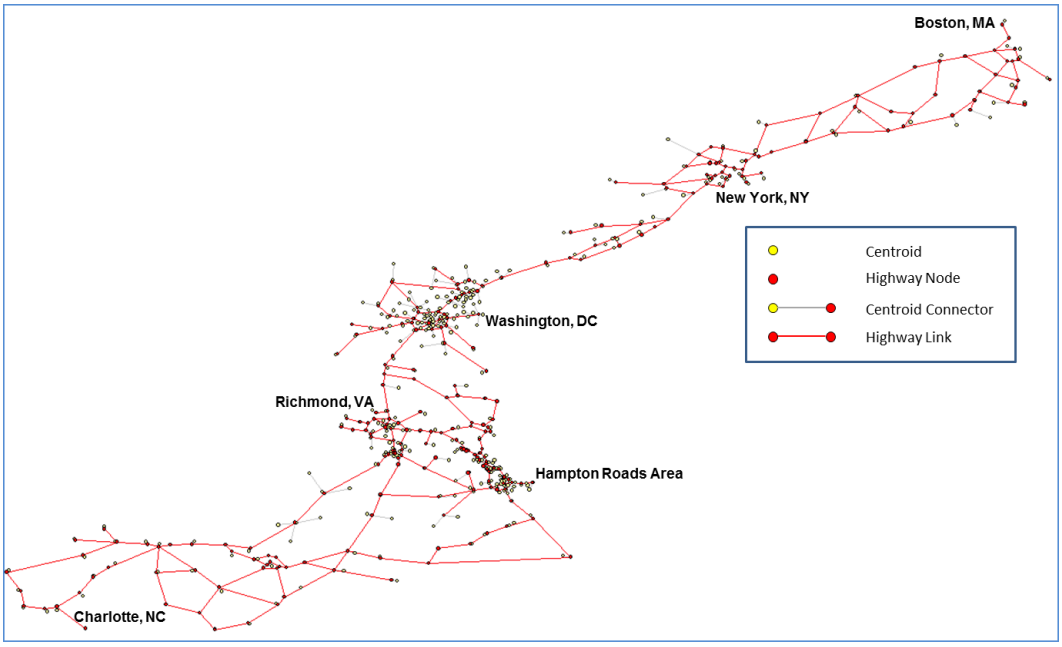
The main roads included in the highway network are shown in Exhibit 6-8

Exhibit 6-8: Major Roads in the COMPASS™ Highway Network

Highway Description	Segment Description
Interstate-64	Norfolk to Richmond
US 460	Suffolk to Richmond
Interstate-95	Richmond to Boston
Interstate-295	Petersburg to Richmond

The highway network of the corridor area coded in COMPASS™ is shown in Exhibit 6-9.

Exhibit 6-9: COMPASS™ Highway Network for the Study Area

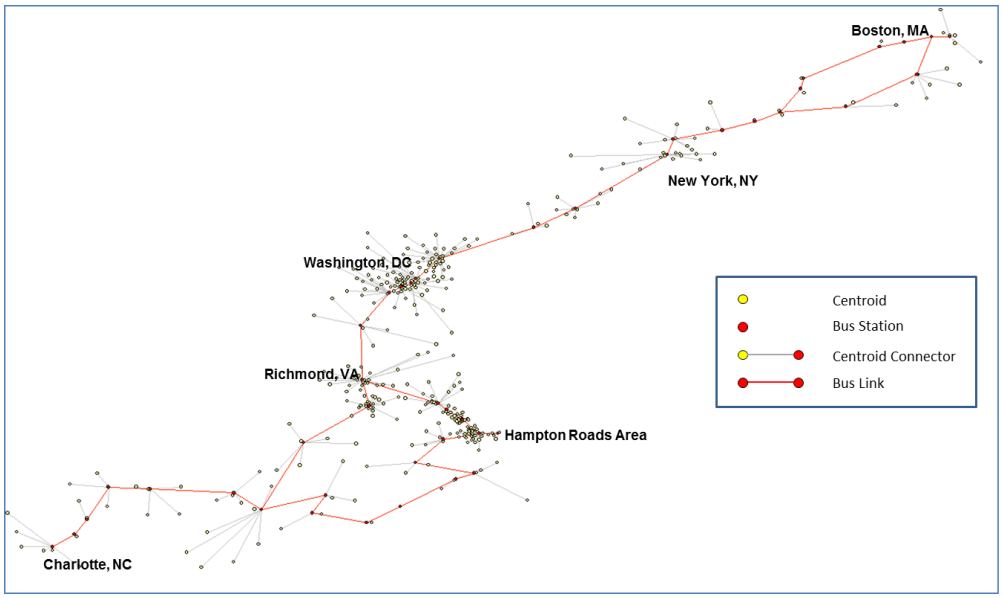


Air network attributes contain a range of variables that include time and distance between airports, airfares, and connection times. Travel times, frequencies and fares were derived from official airport websites, websites of the airlines serving airports in the study area, and the BTS 10% sample of airline tickets. Exhibit 6-10 shows the air network of the study area coded in COMPASS™.

Exhibit 6-10: COMPASS™ Air Network for the Study Area

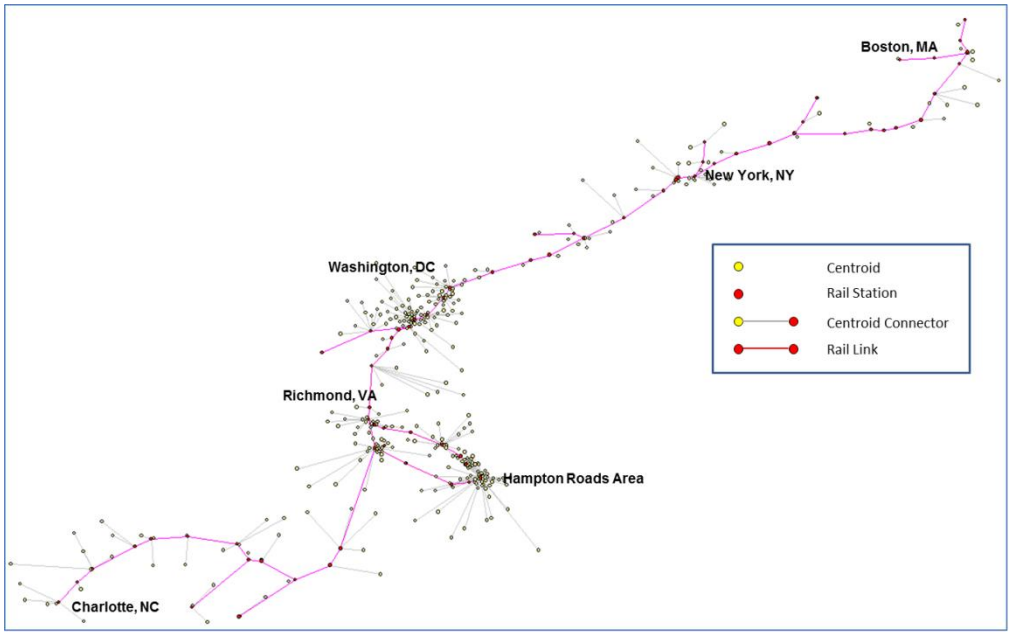
Bus travel data of travel time, fares, and frequencies, were obtained from official schedules of Greyhound and MegaBus. Exhibit 6-11 shows the bus network of the study area coded in COMPASS™.

Exhibit 6-11: COMPASS™ Bus Network for the Study Area



Current passenger rail travel data of travel time, fares, and frequencies, were obtained from official schedules of Amtrak. Exhibit 6-12 shows the passenger rail network of the study area coded in COMPASS™.

Exhibit 6-12: COMPASS™ Passenger Rail Network for the Study Area



6.6 ORIGIN-DESTINATION TRIP DATABASE

The multi-modal intercity travel analyses model requires the collection of base year 2012 origin-destination (O-D) trip data describing annual personal trips between zone pairs. For each O-D zone pair, the annual personal trips are identified by mode (auto, air, and bus) and by trip purpose (Business and Non-Business). Because the goal of the study is to evaluate intercity travel, the O-D data collected for the model reflects travel between zones (i.e., between counties, neighboring states and major urban areas) rather than within zones.

TEMS extracted, aggregated and validated data from a number of sources in order to estimate base travel between origin-destination pairs in the study area. The data sources for the origin-destination trips in the study are:

- The Airline Origin and Destination Survey (DB1B) Air Ticket Database
- T-100 Air Market and Segment Database
- Greyhound and Megabus Schedules
- Previous travel origin-destination surveys
- State department of transportation (Virginia, Maryland, Washington, DC, North Carolina, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island and Massachusetts) highway traffic volume Average Annual Daily Traffic (AADT) data
- Amtrak passenger rail ridership data
- Amtrak station volume data
- TEMS 2012 Virginia Travel Survey

The travel demand forecast model requires the base trip information for all modes between each zone pair. In some cases this can be achieved directly from the data sources, while in other cases the data providers only have origin-destination trip information at an aggregated level (e.g., AADT data, station-to-station trip and station volume data). Where that is the case, a data enhancement process of trip simulation and access/egress simulation needed to be conducted to estimate the zone-to-zone trip volume. The data enhancement process is shown in Exhibit 6-13.

For the auto mode, the quality of the origin-destination trip data was validated by comparing it to AADTs and traffic counts on major highways and adjustments have been made when necessary. For public travel modes, the origin-destination trip data was validated by examining station volumes and segment loadings.

Exhibit 6-13: Zone-to-Zone Origin-Destination Trip Matrix Generation and Validation

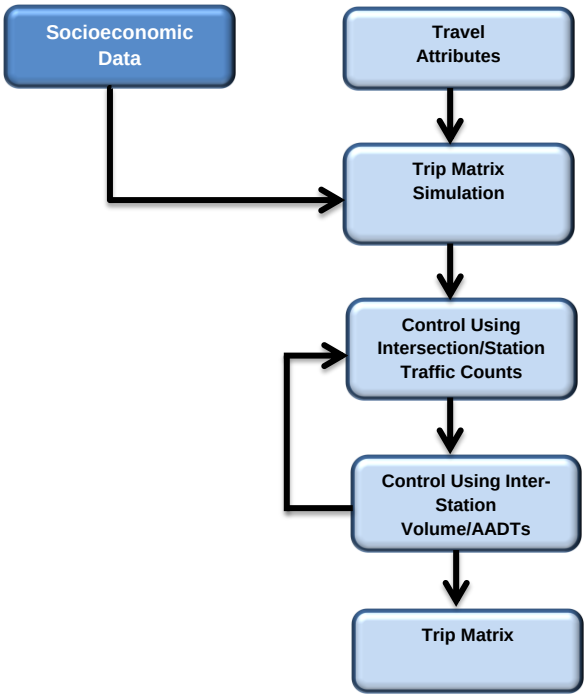
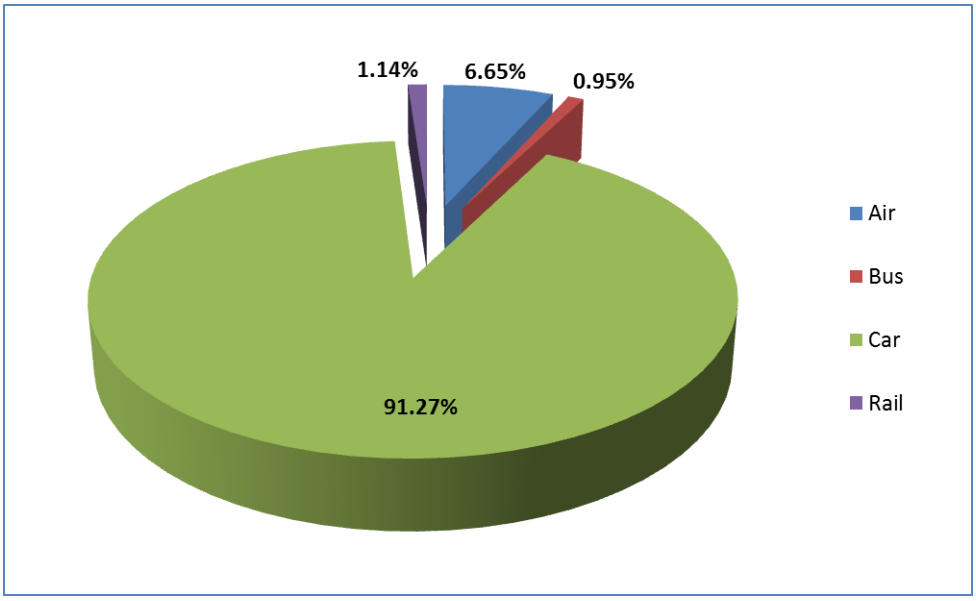


Exhibit 6-14 shows the base 2012 travel market share of rail, air, bus, and auto modes. It can be seen that auto mode dominates the travel market with 91 percent of market share. Public modes have 9 percent of travel market share.

Exhibit 6-14: 2012 Base Travel Market Share by Mode



6.7 STATED PREFERENCE SURVEY

The Stated Preference Analysis was based on results from a broad range of collected stated preference survey forms. Stated Preference Survey method uses a quota sampling approach as a fast and effective way of gathering consumer information on the importance of different travel decisions. This includes such issues as how travelers value travel time (for auto and transit modes) and how they value frequency of service and access time (for transit modes). A quota survey, as opposed to a random survey or a focus group study, is particularly effective in ensuring that all the important travel attributes are measured for the whole population at minimum cost. The quota survey, which has been widely adopted for public opinion surveys, is based on the development of representative "quotas" of the traveling public. The TEMS analysis requires that, two sets of data be collected: (1) the data that define the "travel behavior" quota and (2) the data that define the "personal profile" quota for the individuals surveyed. This allows the data to be stratified by such factors as trip length, income, and group size.

This section describes the stated preference survey process including the methodology used, sample size, survey forms, target locations, and dates of survey deployment along with survey results and analysis.

6.7.1 SURVEY PROCESS

The essence of the stated preference technique is to ask people making trips in the corridor to make a series of trade-off choices based on different combinations of travel time, frequency and cost. Stated preference analysis has been used extensively by TEMS to assess new travel options relating to time, fares, frequency, comfort and reliability for rail, air, and bus services. Tests of the technique in a series of before and after evaluations in North America have produced exceedingly good results. In particular, these tests found that the use of "abstract mode" questions in conjunction with "trade-off analysis" produced reliable results.

Two specific trade-offs were analyzed and used for this study:

- Choices between travel times and travel costs to derive incremental Values of Time for all modes
- Choices between headway times (frequency of service) and travel costs to derive incremental Values of Frequency for transit users.

One part of the survey contains revealed preference questions while the other part contains questions that aim on defining the travel behavior of the surveyed individuals. The revealed preference questions which are the profile data collected from the surveys are used in conjunction with origin-destination and census data to ensure that the stated preference survey can be effectively expanded to properly represent the total population. The collected travel behavior data provides the critical part of the data needed to estimate the generalized cost of travel.

Generalized cost of travel between two zones estimates the impact of improvements in the transportation system on the overall level of trip making. It is typically defined in travel time (i.e., minutes) rather than dollars. Costs are converted to time by applying appropriate conversion factors, as shown in Equation 1. The generalized cost (GC) of travel between zones i and j for mode m and trip purpose p is calculated as follows:

Equation 1:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} + \frac{VOF_{mp} * OH * \exp(\alpha * F)}{VOT_{mp} * \alpha * F^{2}_{ijm}}$$

Where,

TT_{ijm} = Travel Time between zones i and j for mode m (in-vehicle time + station wait time + connection wait time + access/egress time + interchange penalty), with waiting, connect and access/egress time multiplied by a factor (greater than 1) to account for the additional disutility felt by travelers for these activities[1]

TC_{ijmp} = Travel Cost between zones i and j for mode m and trip purpose p (fare + access/egress cost for public modes, operating costs for auto)

VOT_{mp} = Value of Time for mode m and trip purpose p

VOF_{mp} = Value of Frequency for mode m and trip purpose p

F_{ijm} = Frequency in departures per week between zones i and j for mode m

α = Frequency damping factor

OH = Operating hours per week

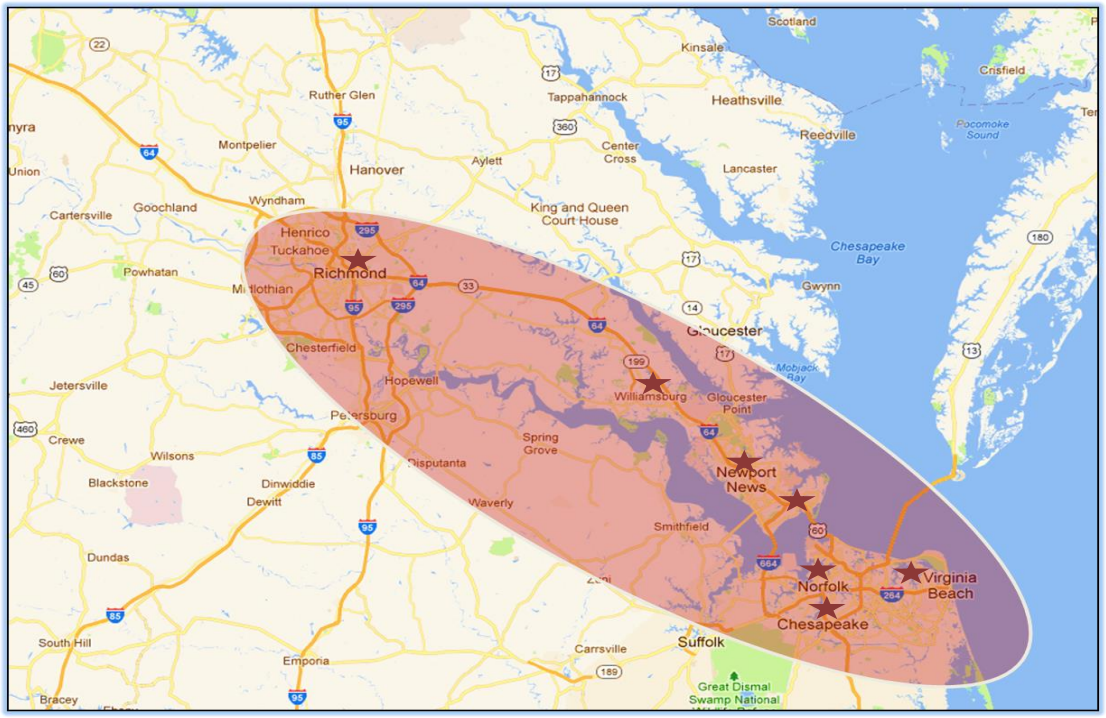
Value of time is the amount of money (dollars/hour) an individual is willing to pay to save a specified amount of travel time, the value of frequency is the amount of money (dollars/hour) an individual is willing to pay to reduce the time between departures when traveling on public transportation, and the value of access is the amount of money (dollars/hour) an individual is willing to pay for the access time to a mode (e.g. the airport, HSR station, railroad station, bus station) to gain easier access to someplace (e.g., an airport). Station wait time is the time spent at the station before departure and after arrival. On trips with connections, there would be additional wait times incurred at the connecting station. Wait times are weighted higher than in-vehicle time in the generalized cost formula to reflect their higher disutility as found from previous studies.

In terms of the size of the survey for each of the quota groups identified - usually up to 12 primary groups. It has been shown that a sample as small as 20 individuals[2] is statistically significant to define the behavioral choices of each group. These primary groups are based on 4 mode groups - auto and transit (that includes air, rail and bus) to 3 purpose groups commuter, business, and other (that includes shopping and social). To improve statistical reliability, TEMS typically seeks 40 to 100 respondents per quota. This means that between 500 and 1,500 surveys are needed for a stated preference survey analysis. The minimum of 1,200-2,000 surveys was set as a goal.

[1] Travel time includes the rest time if travel is by private auto.
[2] According to Stirrings Approximation where the ratio of the actual value (n) and its factorial (n!) is closer to 1.

A very important part of the survey process is to identify the desirable survey locations. Exhibit 6-15 shows the Stated Preference Survey locations map covering Richmond, Williamsburg, Newport News, Hampton, Norfolk, Chesapeake, and Virginia Beach. The surveys were conducted both electronically and also in the field. The main aim of the surveys was to target all 12 quota groups (i.e., Business, Commuters, and for other purpose such as shopping and other social events for both auto and transit users).

Exhibit 6-15: Survey Area



The field Stated Preference Survey captured:

- Rail Users: With the help of Amtrak officials approval, a survey was conducted inside the train station at Richmond, VA capturing both boarding and departing passengers from Newport News to Richmond Amtrak service users and vice versa. The boarding passengers were captured while they were waiting for the train arrivals and departing passengers were captured while they were waiting for their ride;
- Auto Users: With the help of the Virginia Department of Motor Vehicles authority, a survey was conducted at their facilities located at Richmond central, Chesapeake, and Virginia Beach. Patrons were interviewed at these facilities by approaching only those who were seated and were waiting to be called;
- Air Mode Users: With the help of Norfolk International Airport Authority, the air travelers from Norfolk to BWI (Baltimore –Washington Area), to Philadelphia and to New York were interviewed at the baggage claim areas, lobby and outside the security clearance areas;
- Bus Users: With the help of Megabus officials, bus passengers traveling from Richmond to Hampton Roads and Richmond to Washington, DC were interviewed; and

- All Four Mode Users: With the help of Public and Private Organizations such as Virginia Beach Vision, Inc., Greater Williamsburg Chamber & Tourism, Hampton Roads Economic Development Alliance (HREDA) and U.S. NAVY, online survey responses were collected from individuals located in Hampton Roads area, Williamsburg and Newport News area.

Pilot surveys were also conducted prior to actual field and online surveys to test the survey questionnaire. This provided a validation of the survey design and helped the scaling of the stated preference questions so that respondents did "trade" time and cost when filling in the survey forms. Minor adjustments to wording of questions and format were made to improve the readability of the forms. The surveys were kept to one-page, one-side only. Most interviewees filled out the form themselves in 5-10 minutes.

Field and online survey deployment are shown in Exhibit 6-16 The survey was conducted in May 2012 with interviews between May 11, 2012 and May 20, 2012 TEMS collected 2,736 surveys, and exceeded their target range and these results will be discussed in the following section.

Exhibit 6-16: On-Site Survey Team Actual Deployment & Online Survey

	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
	11-May	12-May	13-May	14-May	15-May	16-May	17-May	18-May	19-May	20-May
Newport News-Richmond Amtrak Service										
Richmond Central Auto Users										
Chesapeake Auto Users										
Virginia Beach Auto Users										
Norfolk-BWI, Philadelphia, New York Air Travelers										
Richmond-Hampton Roads, Washington,DC Bus Service										

	Mon	Tue	Wed	Thu	Fri	…	…	Wed	Thu	Fri
	30-Apr	1-May	2-May	3-May	4-May	…	…	6-Jun	7-Jun	8-Jun
Online Survey										

6.7.2 SURVEY RESULTS AND ANALYSIS

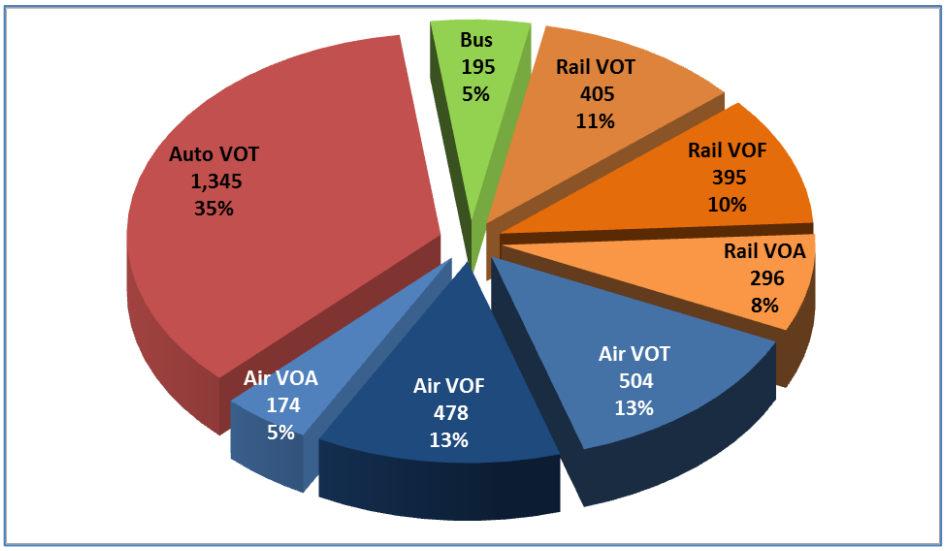
TEMS collected 2,736 surveys, and exceeded their target of 1,900 as shown in Exhibit 6-17 showing exceeded actual survey counts against the survey targets for each location except for bus locations, which almost achieved the target.

Exhibit 6-17: Target vs. Actual Survey Count per Location

Location	Survey Target	Field + Online Count (Actual)
DMV	800	1,377
Airport	500	573
Amtrak	500	690
Bus	100	96
Total	**1,900**	**2,736**

Behavioral attributes reflect the behavior of the respondent when travel conditions change. For the purpose of this study, stated preference surveys collected the information necessary to identify the Value of Time (VOT)[3] for all travelers, the Value of Frequency (VOF)[4] and the Value of Access (VOA)[5]. There were separate forms for each mode and questions were unique for VOT, VOF and VOA. Exhibit 6-18 shows that a total of VOT, VOF and VOA responses for all modes were 3,792.

Exhibit 6-18: VOT, VOF, VOA Counts per Mode[6]



The responses captured by the revealed part of the questionnaire, show that 9% of responses were from commuters and travel to/from school, 14% from business travelers, 77% response was from leisure

[3] Value of Time (VOT) is the amount of money (dollars/hour) an individual is willing to pay to save a specified amount of travel time.
[4] Value of Frequency (VOF) is the amount of money (dollars/hour) an individual is willing to pay to reduce the time between departures when traveling on public transportation.

[5] Value of Access (VOA) is the amount of money (dollars/hour) an individual is willing to pay for the improved access time to a mode (e.g. the airport, HSR station, railroad station, bus station) to gain easier access to someplace (like airport).

[6] This total count of VOT, VOF and VOA per mode equals 3,792 and these counts are not equal to total survey counts as each transit respondent (most of them) filed out two stated preference questionnaires.

travelers for all modes as shown in Exhibit 6-19. Other as indicated by the respondents include visit family, friends, graduation, baseball game, etc.

Exhibit 6-19: Purpose of Travel Responses

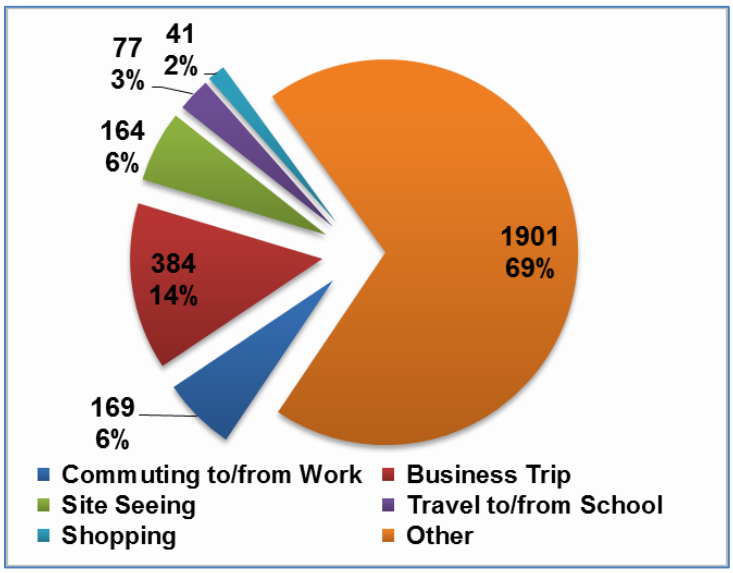
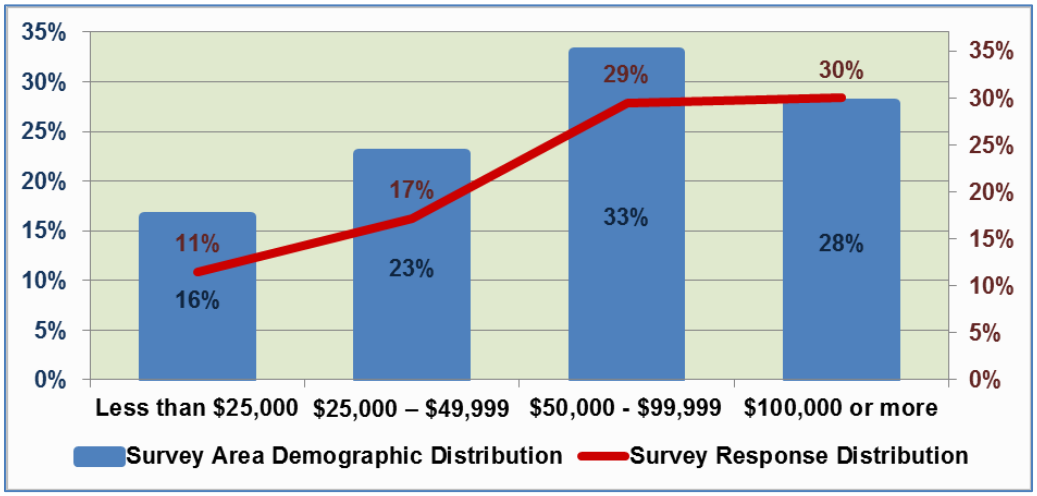


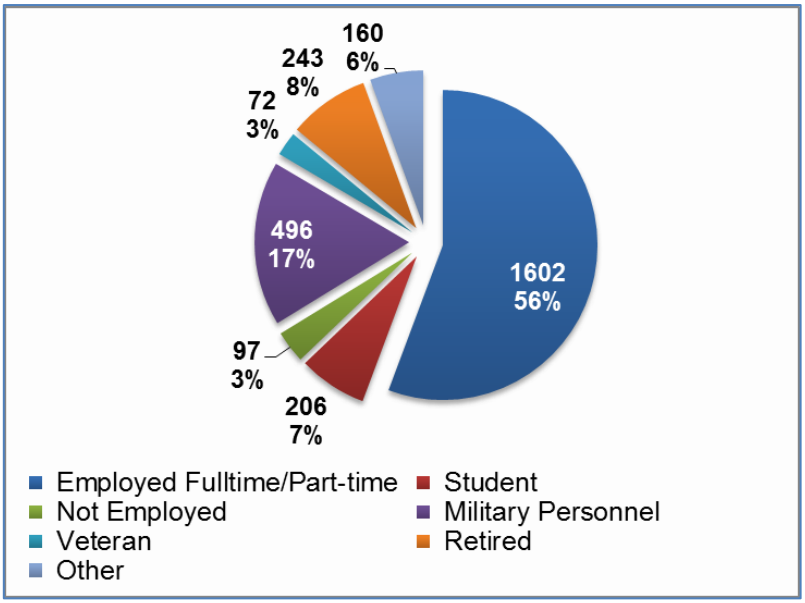
Exhibit 6-20 illustrates distribution of average number of household by income groups along the Survey Study Area corridor in comparison with statistical and survey data. It is seen in the Exhibit that survey responses closely followed most of the demographic distribution with a very slight increase of greater than $100,000 income group. This shows that the survey responses were effectively represented, and the margin of error is only ±6%.

Exhibit 6-20: Distribution of Average Number of Households by Income



The employment type responses from the survey as shown in Exhibit 6-21 was that 56% of the responses were from employed individuals, 17% were from military personnel's, 8% were from retired individuals, 7% were from students, 3% were from veterans, 3% were from unemployed individuals, and 6% were from other where other as indicated by individuals were home-maker, self-employed, etc.

Exhibit 6-21: Employment Type Responses[7]



6.7.3 BEHAVIORAL ATTRIBUTES

Each of these three variables (VOT, VOF and VOA) has been analyzed using the "trade-off' method. The Trade-Off Analysis identifies how individuals choose between time and money in selecting travel options. Two trade-off analysis methods, Binary Logit Method and Direct Comparison Method, were employed to analyze the Attitudinal Survey Data and determine Values of Time (VOT's), Values of Frequency (VOF's), and Values of Access (VOA's).

In the Comparison Method, the trade-off choices made by individuals are ranked in descending or ascending (VOT, VOF or VOA) order, along with the individual's choice between time and money and the degree of preference the individual had for that specific trade-off choice. The individual's VOT, VOF or VOA is then determined by identifying the point of inflection, or the point at which an individual changes from spending more time to save money or preferring to spend more money to save time in making a given journey. The Comparison Method provides a clear and detailed understanding of how travelers react to the series of binary choice trade-off questions. Once the individual trade-off values are determined, the results are averaged to give overall population values.

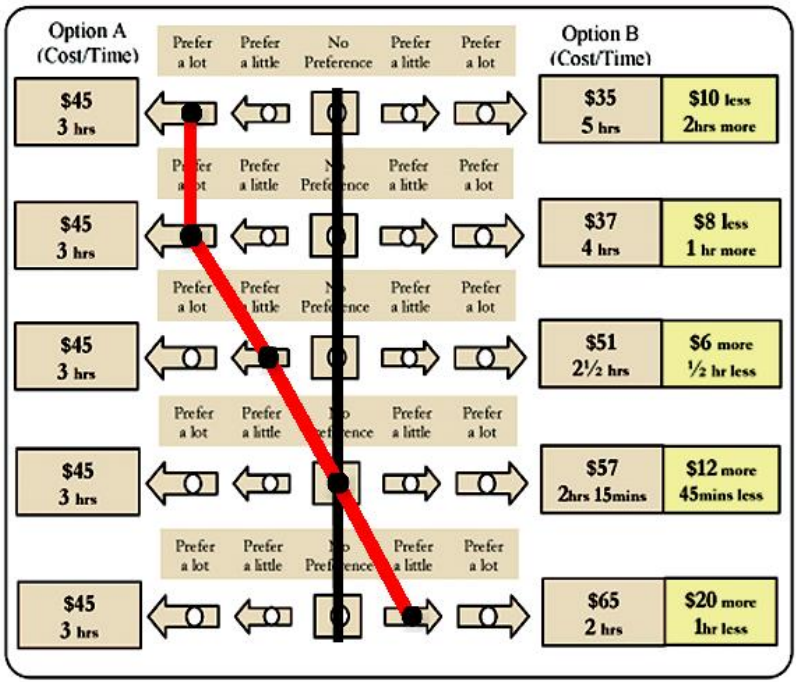
The Binary Logit Method uses a logit curve to calculate the coefficients of the time and cost variables. The individual's VOT, VOF or VOA is derived as the ratio of time and cost coefficients. While this method is a less subjective and more automatic process than the Comparison Method, the statistical rigidity of the Binary Logit Method frequently provides less understanding of travel behavior and less ability to interpret behavior effectively. Furthermore, because this method cannot incorporate the results for individuals who quite rationally do not make a trade-off (preferring time or money options consistently

[7] The total count in Exhibit 2-19 is 2,876 which is more than the actual survey count. The reason being respondents with more than one response were counted separately. For example, student respondents who are employed are counted twice.

over the whole range of trade-off choices), the Binary Logit Method can only be used at most aggregate level.

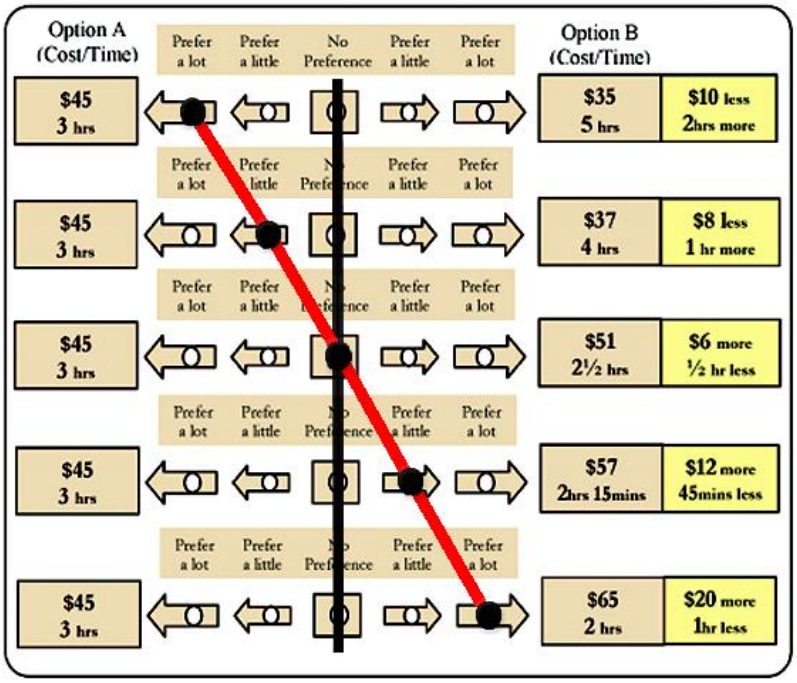
Exhibit 6-22 and 6-23 provides an example of the respondent's trading behavior and illustrates how VOT is calculated using 'trade-off' method. Exhibit 6-23 provides an example of the respondent's non trading behavior[8]. The VOT is calculated for the 'neutral point' located in the intersection between the line indicating 'no preference' and the line connecting the points indicated by the respondent. As seen in Exhibit 6-22 the neutral point or no preference line is located at the fourth row indicating that the respondent is willing to spend $12 more for 45 minutes less. This implies the respondent is willing to spend $16 more for one hour of time saving. Thus, the respondent has a VOT value of $16 per hour.

Exhibit 6-22: VOT calculation based on "Trade-Off" Method: "Trading Behavior"- Example #1



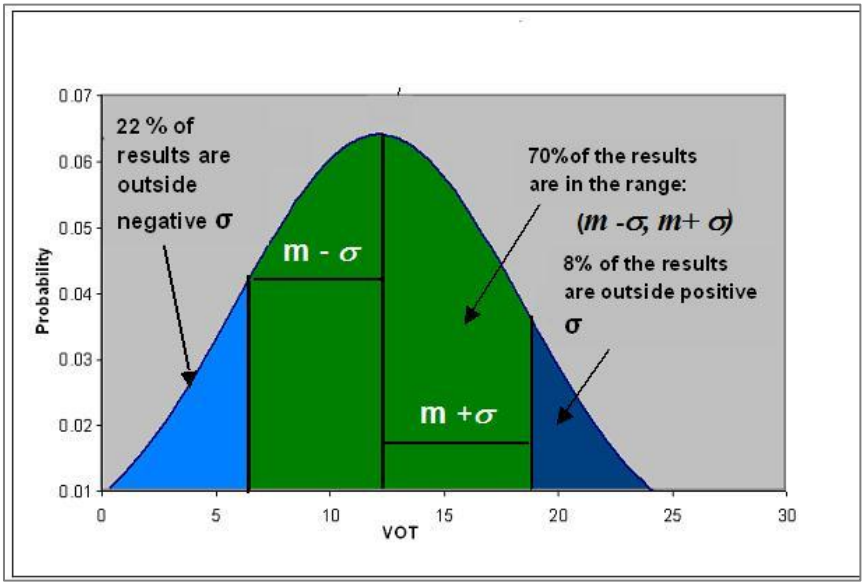
[8] These examples (Exhibit 1-22, 1-23, and 1-25) are drawn from previous TEMS Stated Preference Surveys, and are designed to show how travelers 'trade-off' or 'do not trade-off' between time and cost options.

Exhibit 6-23: VOT calculation based on "Trade-Off" Method: "Trading Behavior" - Example # 2



Not all survey respondents illustrated perfect trading behavior (similar to those shown in Exhibit 6-22 or 6-23). For the data collected, about 30% of the respondents were identified as 'non-traders'. This is shown in Exhibit 6-24, where the 30% (i.e. 22% of very low values of time and 8% of very high values of time) non-traders are equally proportioned between individuals with either very high values of time or very low values of time. The survey is intended to obtain VOT's from the 70% in the middle (i.e., one standard deviation). This is illustrated in Exhibit 6-24.The 30% non-trading behavior example is shown in Exhibit 6-25.

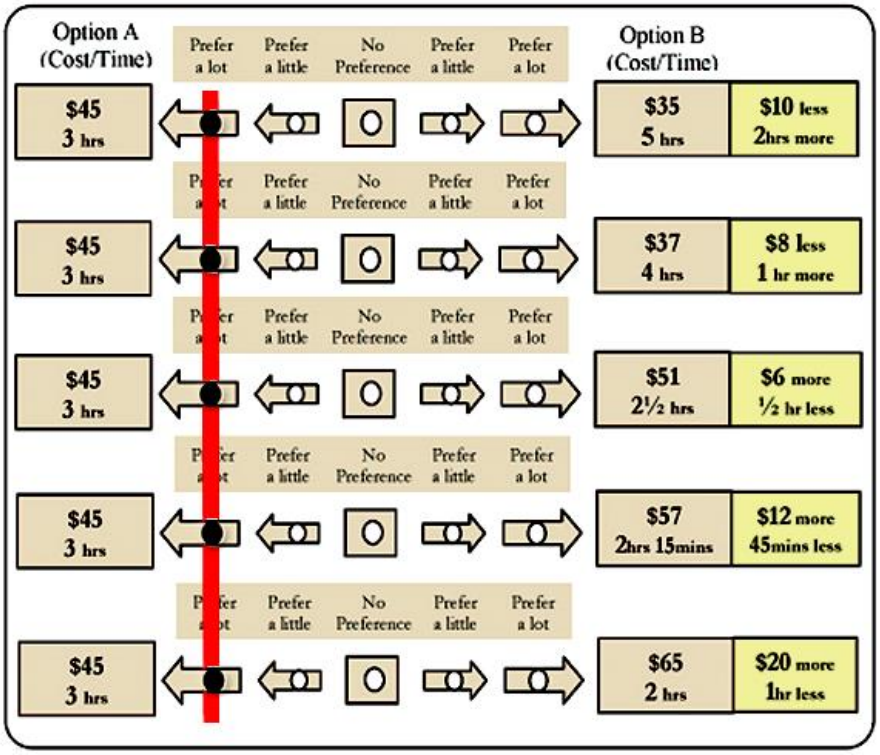
Exhibit 6-24: Distribution of the Non Respondent Error in the Trade-off Analysis of the Collected Survey Data[9]



[9] Normal distribution with one standard deviation above the mean.

VOT calculated based on the example shown in Exhibit 6-25 is assumed to be $45 for three hours ($15 per hour) or less as there is no trading, and the individual is showing a preference to spend time rather than money.

Exhibit 6-25: VOT calculation based on '"Trade-Off" Method: "Non Trading Behavior"



The Stated Preference Survey results of VOT, VOF and VOA calculated for four modes (auto, rail, bus, and air) and three types of purpose (commuter, business and other) are presented in Exhibits 6-26 through 6-28. Based on the calculations, the following observations were made:

- The hierarchical order of VOT is higher for Air access, rail, auto and then bus users., which is the typical trend;
- Business trips have larger VOT, VOF and VOA values than commuter and other trips;
- The VOT, VOF and VOA values are consistent with those of previous studies (e.g., Bay Bridge Travel Survey, 2006, Rocky Mountain Rail Authority (RMRA), 2008) after adjusting to 2012 dollars for similar trip length
- Intercity value of time is larger than intraurban value of time due to longer trip length, this explains why commuters have lower value of time, which have more intraurban trips than other trip purposes

Exhibit 6-26: VOT values by Mode and Purpose of Travel

Value of Time VOT	Business	Commuter	Social
Auto	$19.42	$14.80	$16.88
Bus	$11.07	$7.15	$8.54
Rail	$22.51	$18.80	$17.88
Air	$44.45	-	$31.76

Exhibit 6-27: VOF values by Mode and Purpose of Travel

Value of Frequency VOF	Business	Commuter	Social
Bus	$7.33	$6.50	$7.75
Rail	$18.58	$13.67	$16.13
Air	$28.81	-	$26.28

Exhibit 6-28: VOA values by Mode and Purpose of Travel

Value of Access VOA	Business	Commuter	Social
Bus	-	$8.89	$10.77
Rail	$42.73	$29.15	$37.66
Air	$62.91	-	$47.94

6.8 FUTURE TRAVEL MARKET STRATEGIES

6.8.1 FUEL PRICE FORECASTS

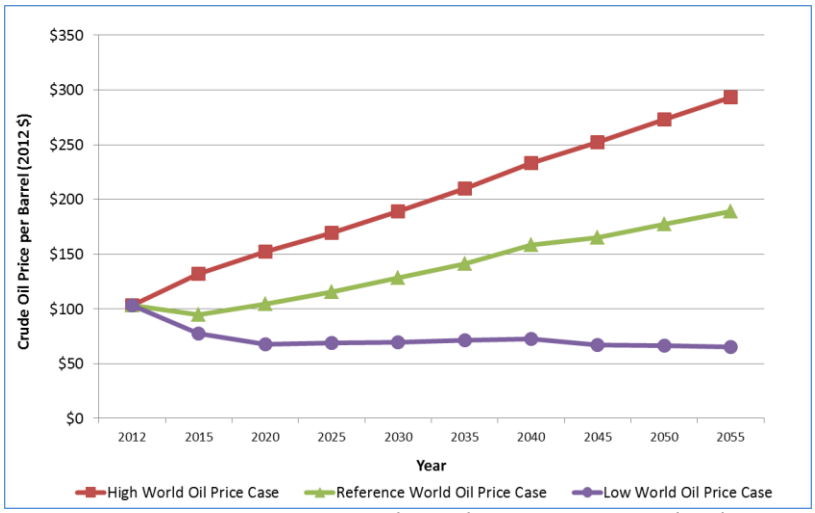
An important factor in the future attractiveness of passenger rail is fuel price. Exhibit 6-28 shows the Energy Information Agency (EIA)[10] projection of crude oil prices for three oil price cases, namely high world oil price case that is aggressive oil price forecast, reference world oil price case that is moderate and is also known as the central case forecast, and the conservative low world oil price case. In this study, the reference case oil price projection was used to estimate transportation cost in future travel market. EIA projects oil price to 2040, the oil price projections after 2040 were estimated based on historical prices and EIA projections. The EIA reference case forecast suggests that crude oil prices are expected to

[10] EIA periodically updates historical and projected oil prices at www.eia.gov/forecasts/aeo/tables_ref.cfm

be $116 per barrel (2012$) in 2025 and will remain at that high level and will increase to $142 per barrel (2012$) in 2035.

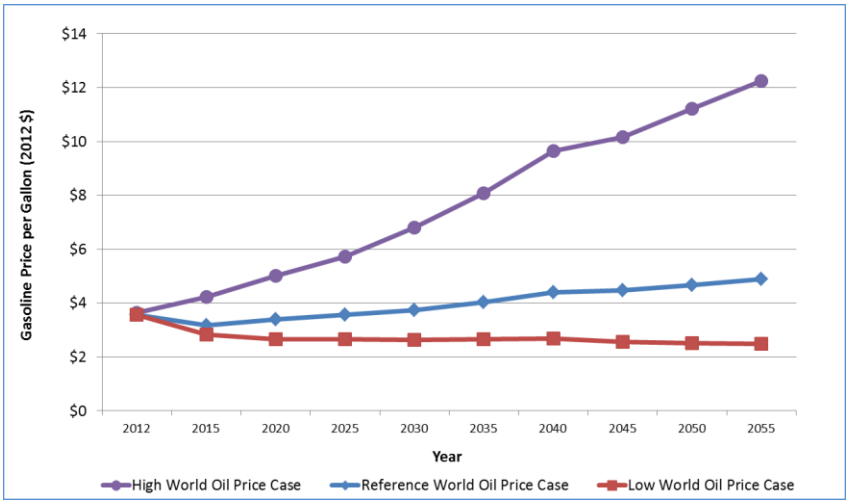
EIA has also developed a future retail gasoline price forecast, which is shown in Exhibit 6-29. The implication of this is a reference case gasoline price of $3.6 per gallon (2012$) in 2025, with a high case price of $5.7 per gallon and a low case price of $2.7 per gallon. Since 2012 annual average gas price of Midwest region is about $3.6[11] per gallon in a weak economy environment, $4~5 per gallon once the economy starts to grow again seems likely.

Exhibit 6-28:
Crude Oil Price Forecast by EIA



*EIA projections go to 2040, projections beyond 2040 were extrapolated

Exhibit 6-29:
U.S. Retail Gasoline Prices Forecast by EIA



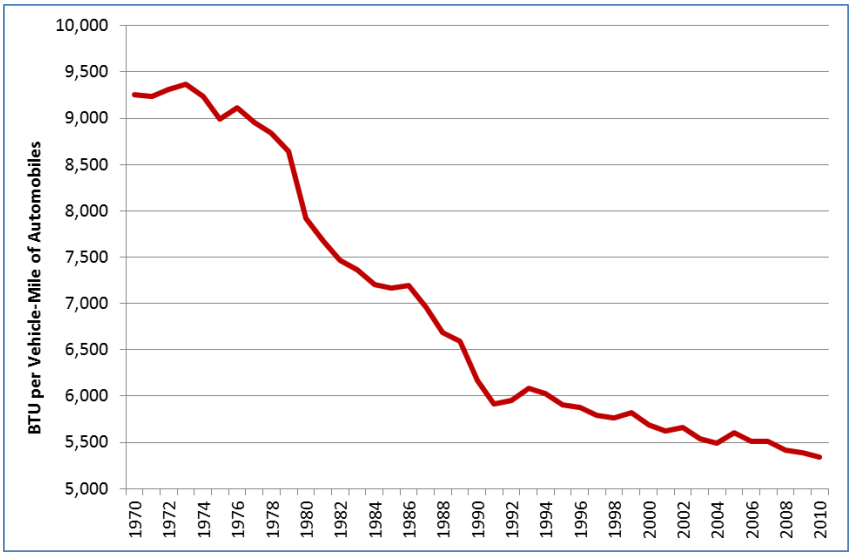
*EIA projections go to 2040, projections beyond 2040 were extrapolated

[11] Weekly Retail Gasoline and Diesel Prices from EIA http://www.eia.gov/dnav/pet/pet_pri_gnd_a_epmr_pte_dpgal_a.htm

6.8.2 VEHICLE FUEL EFFICIENCY FORECASTS

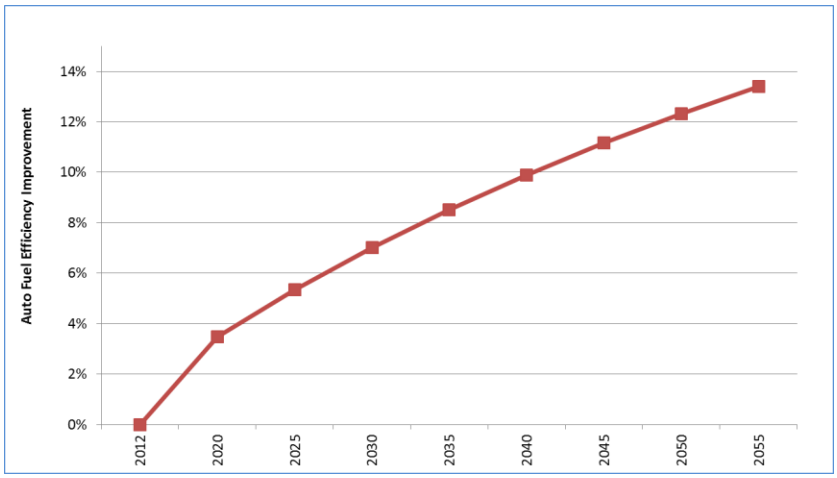
Future improvement in automobile technology is likely to reduce the impact of high gas prices on automobile fuel cost with better fuel efficiency. The Oak Ridge National Laboratory (ORNL) Center for Transportation Analysis (CTA) historical automobile highway energy intensities data has the historical Btu (British thermal unit) per vehicle-mile data for automobiles since 1970 as show in Exhibit 6-30.

Exhibit 6-30: ORNL Historical Highway Automobile Energy Intensities Data



From Exhibit 6-31 it can be seen that automobile fuel efficiency has been improving gradually during the past few decades but the improvement has slowed down in recent years. Future automobile fuel efficiency improvement that was projected and shown in Exhibit 6-31 was based on the historical automobile fuel efficiency data. It shows that the automobile fleet fuel efficiency is expected to improve by nearly 13 percent by 2055.

Exhibit 6-31: Auto Fuel Efficiency Improvement Projections



6.8.3 HIGHWAY TRAFFIC CONGESTION

The average annual travel time growth in the corridor is estimated with the projected highway traffic volume data and the BPR (Bureau of Public Roads) function that can be used to calculate travel time growth with increased traffic volumes:

$$T_f = T_b * [1 + \alpha * \left(\frac{V}{C}\right)^{\beta}]$$

where

T_f is future travel time,

T_b is highway design travel time,

V is traffic volume,

C is highway design capacity,

α , β are calibrated coefficients.

The future highway link volumes are forecasted based on the historic Annual Average Daily Traffic (AADT) from VDOT[12]. Exhibit 6-32 shows historic AADTs and annual average growth rate (AAGR) for six segments on two major highway corridors of the study areas: Interstate 64 and Route 460. As shown in the exhibit, the traffic growth in these two corridors since 2000 is strong. Without significant improvement on these two corridors or building new alternatives, the congestions on these highways will become more and more serious.

Exhibit 6-32: Historic AADT of I64 and Route 460

Route	From	To	2011	2010	2009	2005	2000	AAGR
I64	I-295	New Kent County Line	69,000	68,000	69,000	67,000	62,000	1.0%
I64	SR 33 Eltham Rd	James City County Line	52,000	53,000	54,000	47,000	39,000	2.6%
I64	SR 238 Yorktown Rd	SR 105 Ft Eustis Blvd	88,000	88,000	83,000	86,000	71,000	2.0%
Rte. 460	I-295	74-629	14,000	15,000	16,000	16,000	13,000	0.7%
Rte. 460	Windsor East County Line	Suffolk West County Line	17,000	14,000	14,000	16,000	11,000	4.0%
Rte. 460	Suffolk East County Line	I-664	67,000	67,000	68,000	67,000	55,000	1.8%

[12] http://www.virginiadot.org/info/ct-TrafficCounts.asp

Exhibit 6-33 shows the estimated travel time growths in 2025 for two city pairs in the study area due to increasing highway traffic volumes.

Exhibit 6-33: Highway Travel Time Projections for Two City Pairs

	2012 Travel Time	2025 Estimated Travel Time
Norfolk, VA - Richmond, VA	1Hour40Min	1Hour55Min
Norfolk, VA - Petersburg, VA	1Hour35Min	1Hour43Min

The projected travel times in Exhibit 6-33 are calculated by applying BRP function with forecasted link volumes and capacity. The key assumptions of parameter are same as used in 2004 HRTPO Roads Travel Demand Model[13]. For example, suburban Interstate has the following parameters

- $\alpha = 0.15$
- $\beta = 4$
- Lane capacity = 1875
- Highway link capacity does not change with time

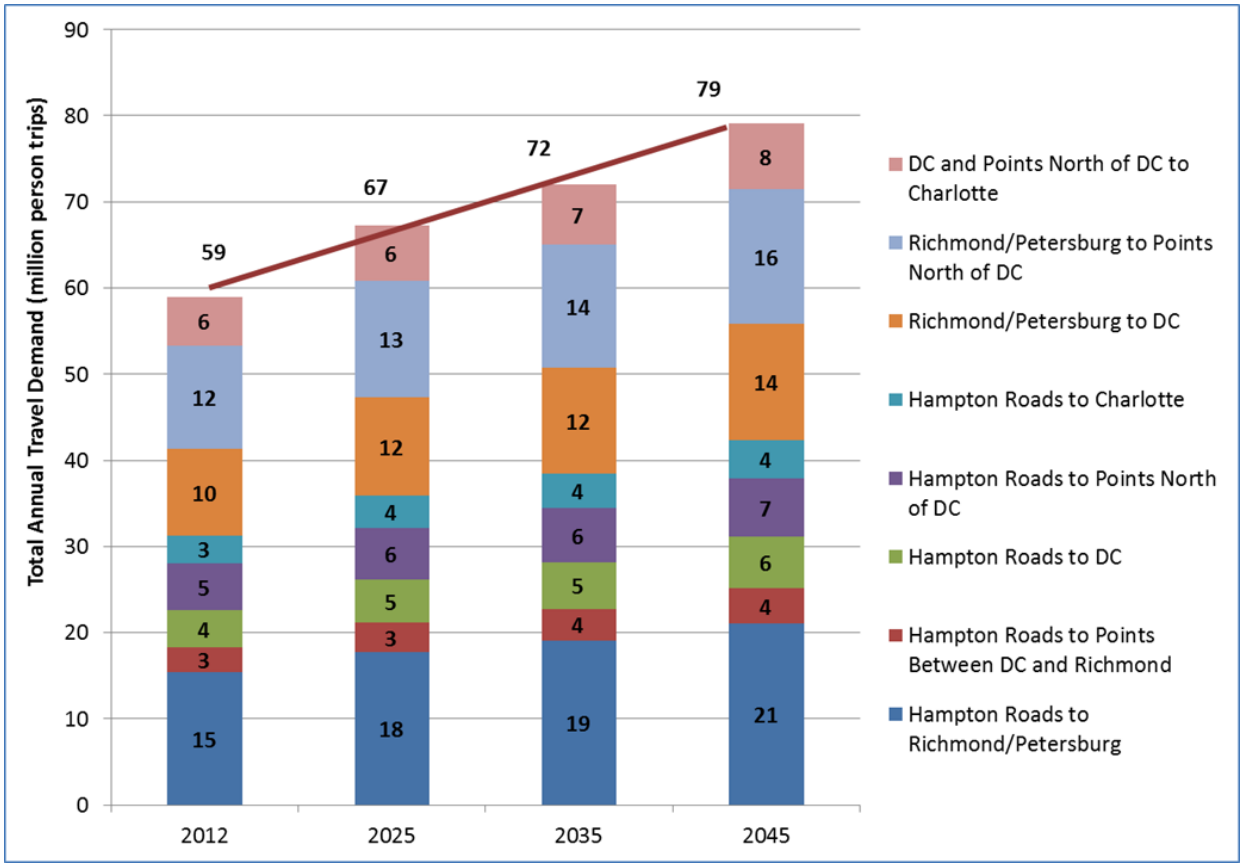
For example, a highway segment around on I64 has seen a traffic volume increase from 39,000 vehicles per day to 85,500 vehicles per day from 2011 to 2025. By applying the BPR function while assuming same route is used between these two cities in the future, it can be calculated that travel time on this highway segment will increase by about 0.5% per year with the BPR function.

6.9 CORRIDOR TOTAL TRAVEL MARKET DEMAND FORECAST

This section presents the Hampton Roads – Richmond - Washington Corridor Total Travel Demand Forecast produced from the results of the *COMPASS*™ Total Demand Model application. While the COMPASS™ analysis considers intercity travel from Boston to Charlotte (See Exhibit 6-4) but is presenting in this section only the demand in the Hampton Roads – Richmond – Washington Corridor. Exhibit 6-34 shows the Hampton Roads – Richmond - Washington Corridor total travel demand forecasts for 2025, 2035, and 2045. It can be seen that the corridor travel demand will increase to 67 million in 2025, to 72 million in 2035, and increases to 79 million in 2045. The average annual corridor travel market growth rate is 0.9 percent, which is in line with the socioeconomic growth within the corridor.

[13] 2000 Hampton Roads Model Validation Memorandum, Virginia Department of Transportation, May 2004

Exhibit 6-34: Study Area Travel Market Forecast – Annual Person Trips for the Whole Study Area that Extends from Boston to Charlotte



6.10 Corridor Travel Market Forecasts for Passenger Rail

The specific ridership and revenue is dependent on the level of train service proposed. Exhibit 6-35 presents the summary of passenger rail service assumptions (strategies) for the passenger rail ridership and revenue forecast. The rail service plan includes station stopping pattern number, train running times for 130 mph and 220 mph options.

Exhibit 6-35: Norfolk to Washington High Speed Train Stopping Pattern

Stations	Super Express	Express	Local
Norfolk	√	√	√
Bowers Hill	√	√	√
Suffolk	–	–	√
Petersburg/Hopewell*	–	√	√
Richmond Main St	√	√	√
Ashland	–	–	√
Fredericksburg	–	√	√
Quantico	–	–	√
Alexandria	√	√	√
Washington Union	√	√	√
130-mph Total Trains	4 trains	5 trains	4 trains
130-mph Time via Petersburg/Hopewell	2:36	2:46	3:01
130-mph Time Richmond Direct	2:31	2:36	2:51
220-mph Total Trains	5 trains	10 trains	3 trains
220-mph Time via Petersburg/Hopewell	1:45	1:55	2:10
220-mph Time Richmond Direct	1:38	1:43	1:58

* Stations Bypassed by Richmond Direct

The Richmond Direct option swings quite far to the east to access Richmond. This leaves open the possibility of services from the Peninsula using the Richmond Direct route from near Roxbury to Richmond, a distance of some 20 miles. This would allow Peninsula trains to operate on a portion of the Norfolk-Richmond segment and would provide an increase in Peninsula train speed to 130 mph going from Roxbury to Richmond and to Washington, DC. Such a connection would also dramatically increase Peninsula traffic to a level to a level beyond just 3 trains per day.

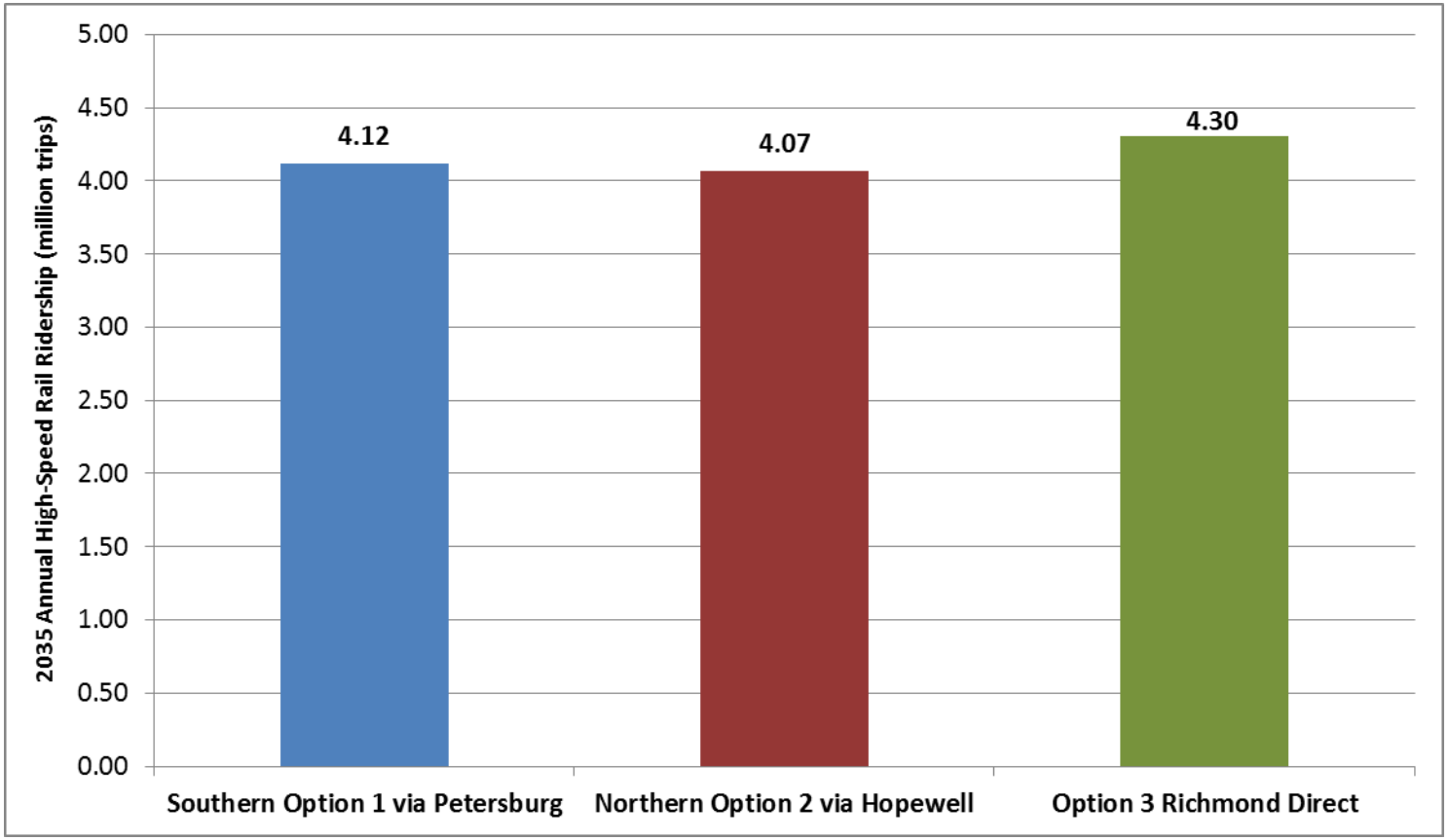
Given this potential synergy of the Richmond Direct Route with the Peninsula, an evaluation was made in Option 4 of developing a high speed connection towards Newport News. This evaluation of a high speed connection considered the geography, topology, and environment along the Peninsula corridor between Roxbury and Newport News. As a preliminary estimate, it was decided that a short (20 mile) connection going from the Richmond Direct route at Roxbury to Toano just outside Williamsburg, would be the most effective option. The terrain for these twenty miles is rural and mostly follows an existing utility right-of way. Development of the Peninsula connection would face similar issues to those faced by Richmond Direct, Option 3.

The preliminary Option 4 route analysis suggests an extension from Roxbury to Toano just outside Williamsburg as being feasible and further route variations may be possible for making this connection. This is a distance of 40 miles from Richmond and would allow high speed diesel operation from just outside Williamsburg to Washington at 130 mph “under the wire” of an electrified Richmond Direct option. This option was identified as the Richmond Direct Improved alternative, Option 4.

Using different route and train service plans, Exhibits 6-36 and 6-37, present the passenger rail ridership forecasts for the Hampton Roads – Richmond – Washington Corridor for 2035. The passenger rail system generates 4.07 to 4.30 million trips in 2035 for 130-mph options. For 220-mph options, the ridership ranges from 5.75 to 6.11 million trips, and the ridership of Option 4 is 8.55 million. A trip is defined as a passenger making a one-way trip and a round trip generates two one way trips.

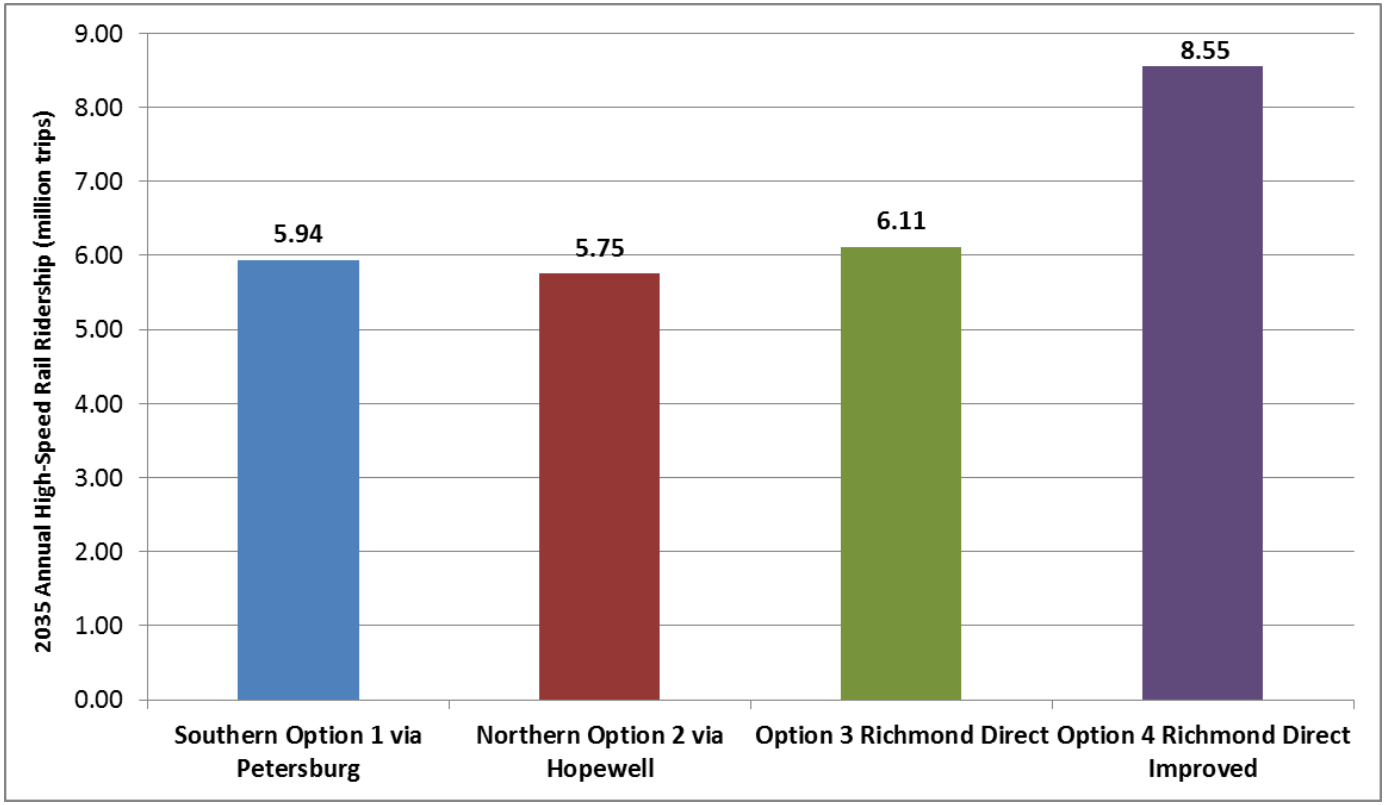
Exhibits 6-38 and 6-39 shows the annual fare-box revenue for years 2035. It can be seen that the annual revenue of 2035 is $216 to 228 million for the 130-mph options and is 362 to 374 million for 220-mph options, and the revenue of Option 4 is 592 million. All revenue forecasts are presented in 2012 dollar values.

Exhibit 6-36: 130-mph High Speed Passenger Rail Ridership Forecast-Annual Person Trips for the Southside Option that Extends from Boston to Charlotte



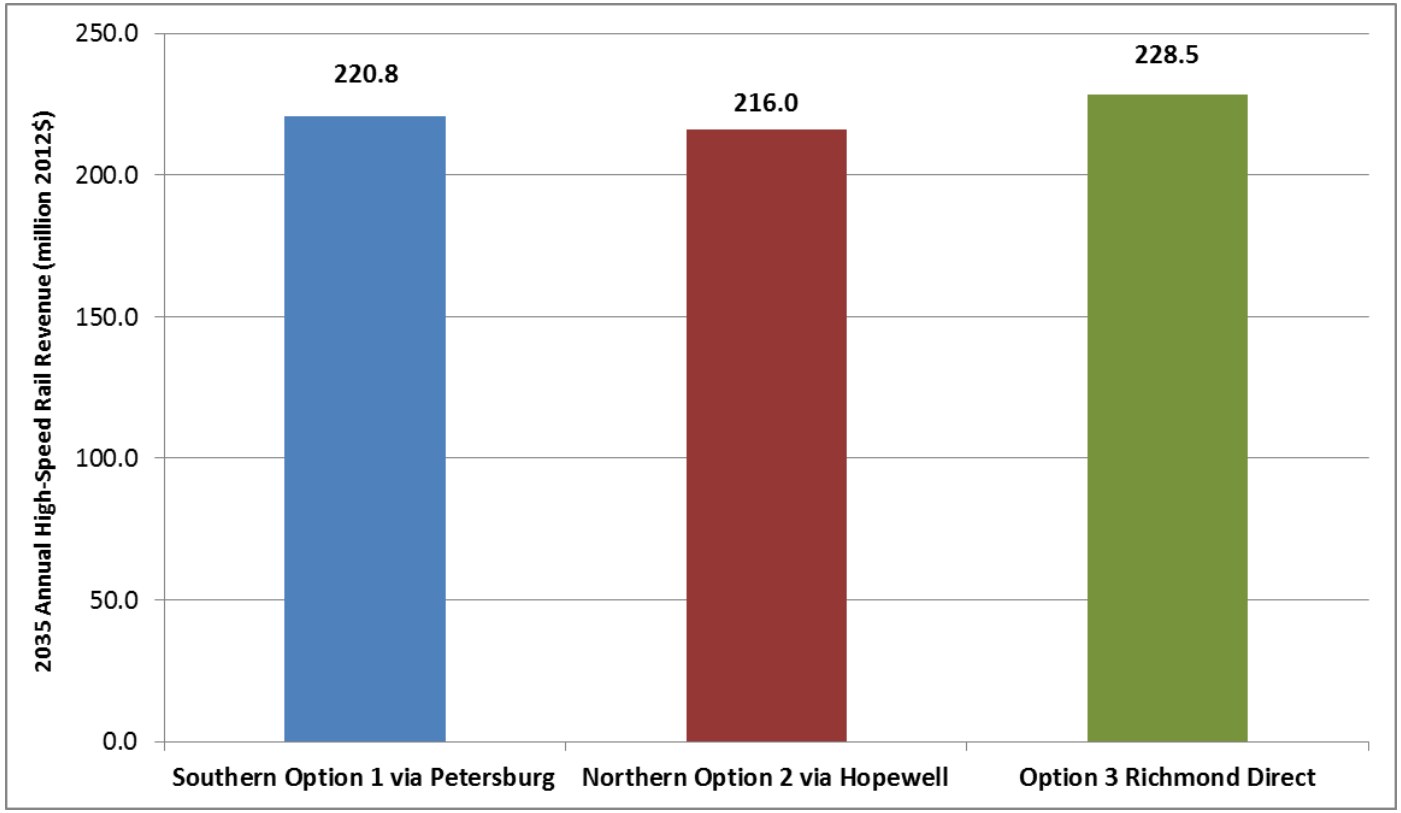
	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct
Hampton Roads to Richmond/Petersburg	0.33	0.33	0.38
Hampton Roads to Points Between DC and Richmond	0.55	0.55	0.68
Hampton Roads to DC	0.79	0.79	0.93
Hampton Roads to Points North of DC	0.34	0.34	0.39

Exhibit 6-37: 220-mph High Speed Passenger Rail Ridership Forecast-Annual Person Trips for the Southside Option and Option 4 Richmond Direct Improved that Extend from Boston to Charlotte



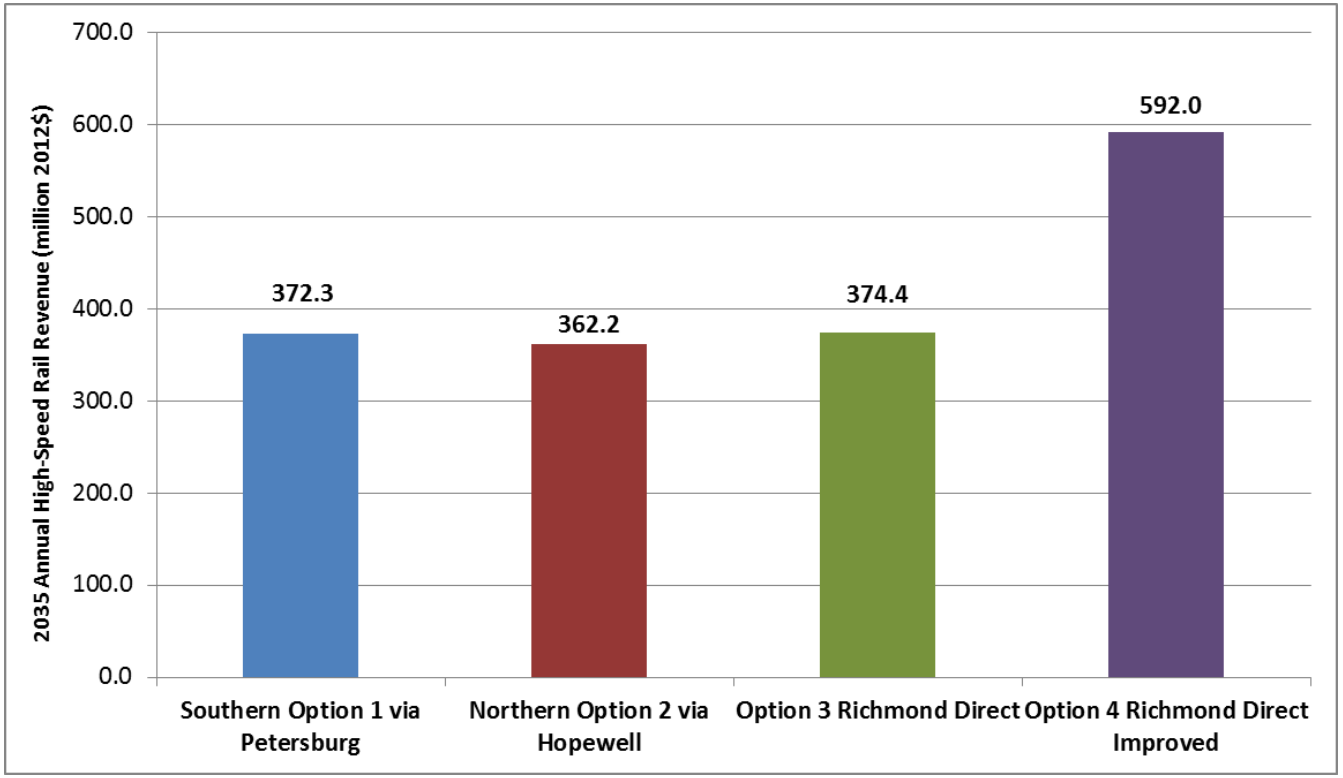
	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct	Option 4 Richmond Direct Improved
Hampton Roads to Richmond/Petersburg	0.51	0.51	0.58	0.97
Hampton Roads to Points Between DC and Richmond	0.99	0.99	1.14	1.91
Hampton Roads to DC	1.25	1.25	1.39	2.15
Hampton Roads to Points North of DC	0.67	0.66	0.75	1.26

Exhibit 6-38: 130-mph High Speed Passenger Rail Revenue Forecast-Annual Revenue for the Southside Option that Extends from Boston to Charlotte



	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct
Hampton Roads to Richmond/Petersburg	8.87	8.80	9.86
Hampton Roads to Points Between DC and Richmond	40.82	40.79	47.69
Hampton Roads to DC	67.53	67.50	75.55
Hampton Roads to Points North of DC	27.81	27.83	30.51

Exhibit 6-39: 220-mph High Speed Passenger Rail Revenue Forecast-Annual Revenue for the Southside Option and Option 4 Richmond Direct Improved that Extend from Boston to Charlotte



	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct	Option 4 Richmond Direct Improved
Hampton Roads to Richmond/Petersburg	17.22	17.10	18.72	36.40
Hampton Roads to Points Between DC and Richmond	79.07	78.98	86.07	150.52
Hampton Roads to DC	113.53	113.43	119.73	200.57
Hampton Roads to Points North of DC	60.98	60.64	65.80	120.01

The corridor transportation mode market share forecasts in 2025 are shown in Exhibits 6-40 thru 6-43. The auto mode continues to demonstrate its dominance in the corridor maintaining a market share above 80 percent in 2025. Rail market share will increase to more than five percent for 130-mph options, and will be around eight to eleven percent for 220-mph options. Air market share will be around seven percent. Bus market share will remain less than one percent.

Exhibit 6-40: Intercity Travel Market Share Forecast – Southern Option 1 via Petersburg 2035

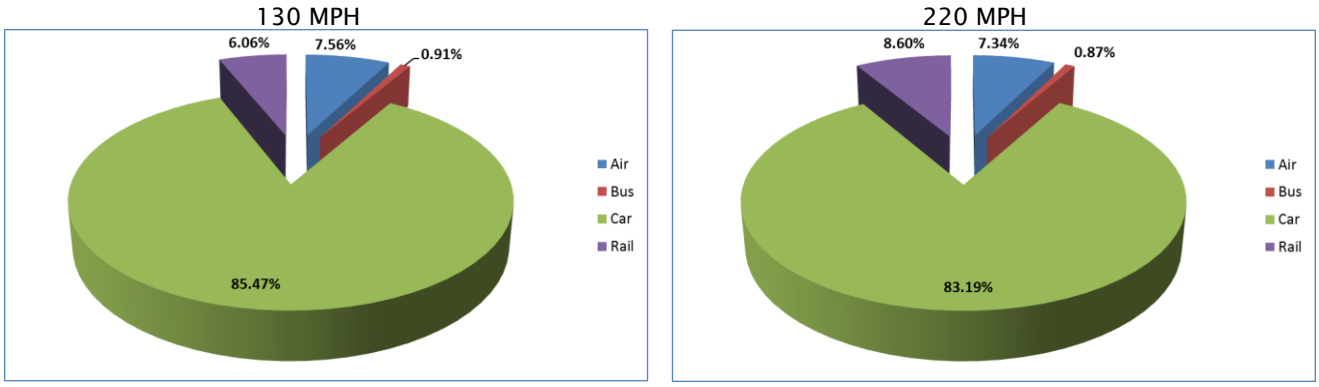


Exhibit 6-41: Intercity Travel Market Share Forecast – Northern Option 2 via Hopewell 2035

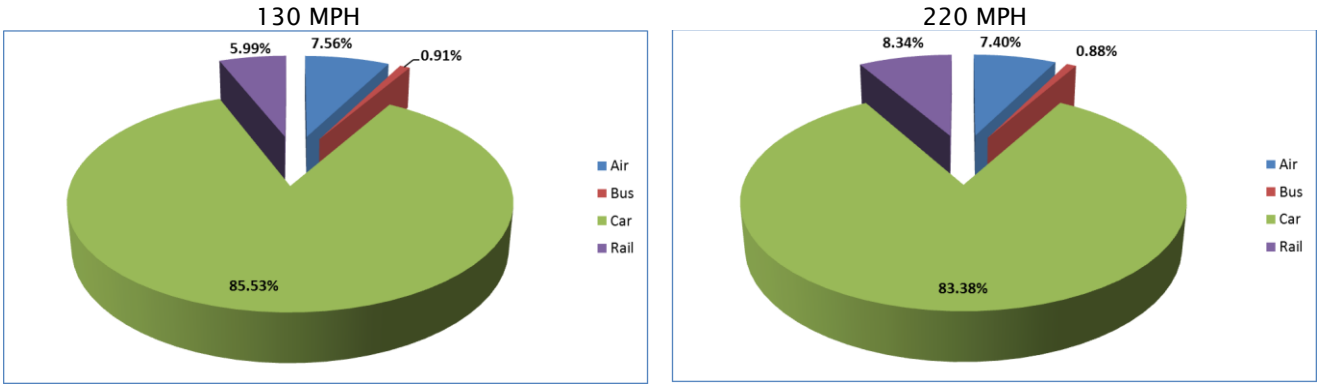


Exhibit 6-42: Intercity Travel Market Share Forecast – Option 3 Richmond Direct 2035

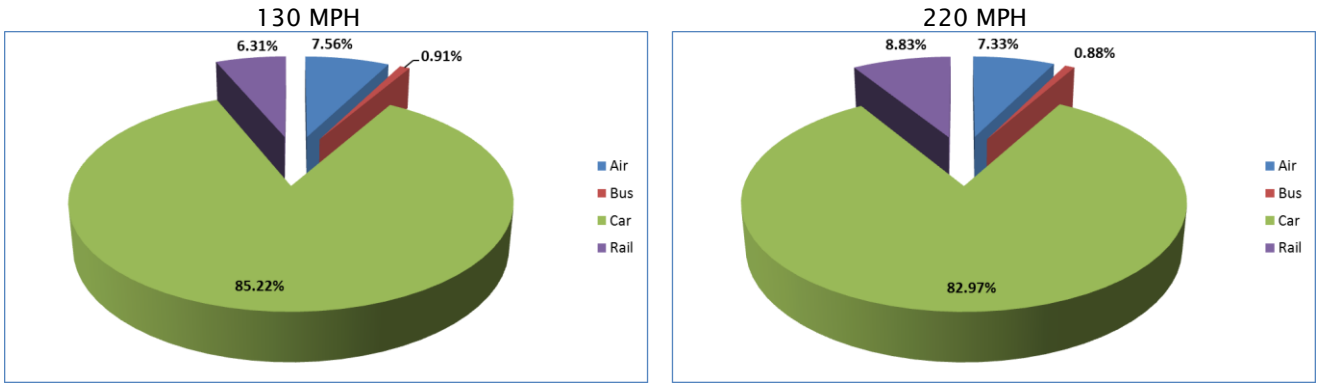
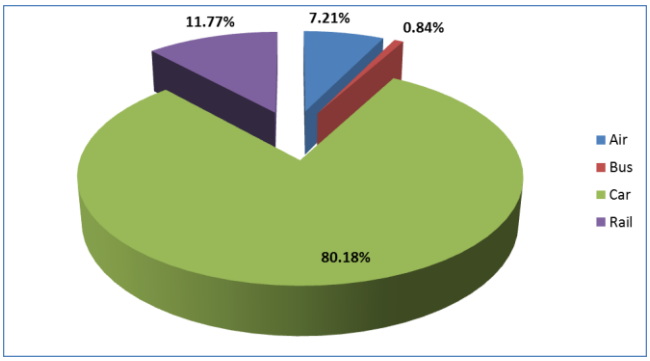


Exhibit 6-43: Intercity Travel Market Share Forecast – Option 4 Richmond Direct Improved 2035



Exhibits 6-44 thru 6-47 illustrate the sources of the rail trips. The trips diverted from other modes-primarily auto, are the most important source of rail trips, which accounts for 62 to 68 percent of overall rail travel market. Induced travel demand in the corridor as result of the new passenger rail service is 7.8 to 16 percent of the rail travel market. As for the diverted trips from other modes, more than 90 percent trips are from auto mode, but the auto driving still dominates future travel market, as this is still a very effective option for shorter trips in the current Hampton Roads – Richmond – Washington Corridor.

Exhibit 6-44: Sources of HSR Trips- Southern Option 1 via Petersburg 2035

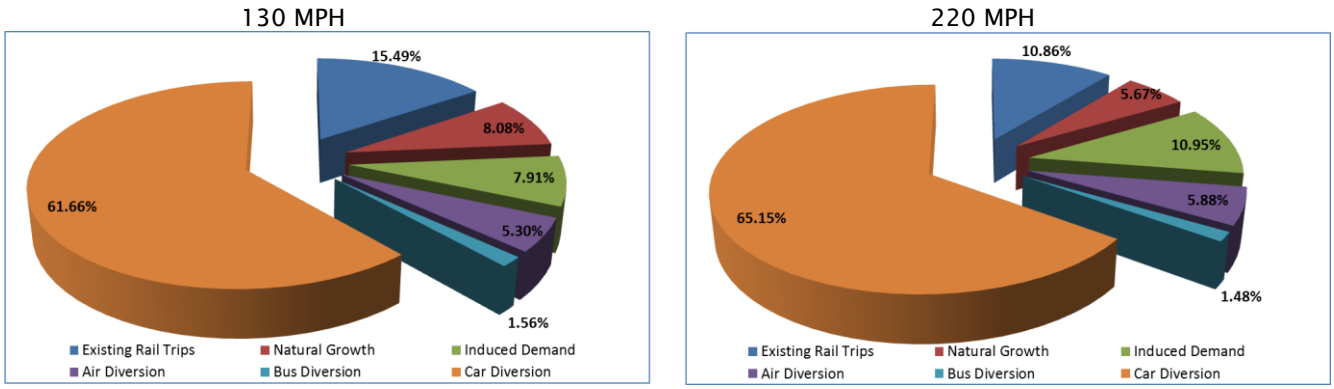


Exhibit 6-45: Sources of HSR Trips- Northern Option 2 via Hopewell 2035

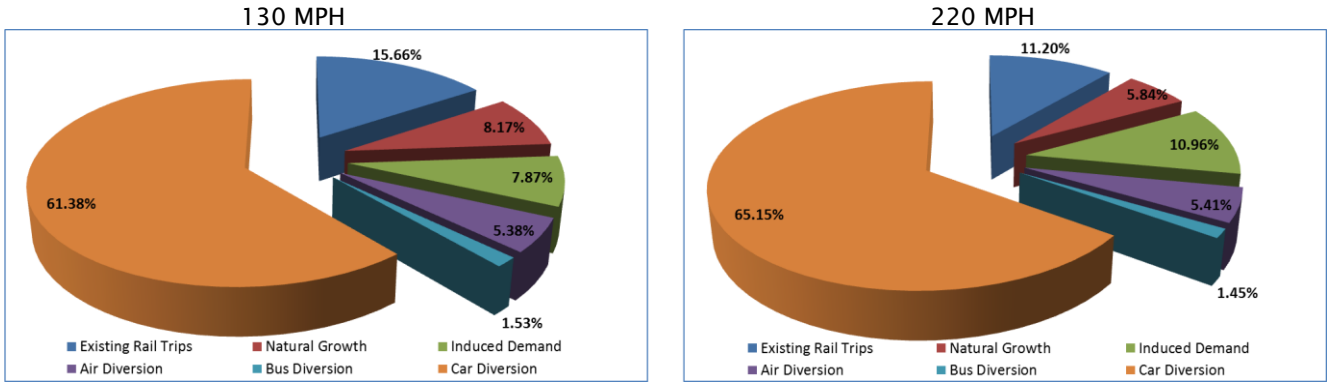


Exhibit 6-46: Sources of HSR Trips- Option 3 Richmond Direct 2035

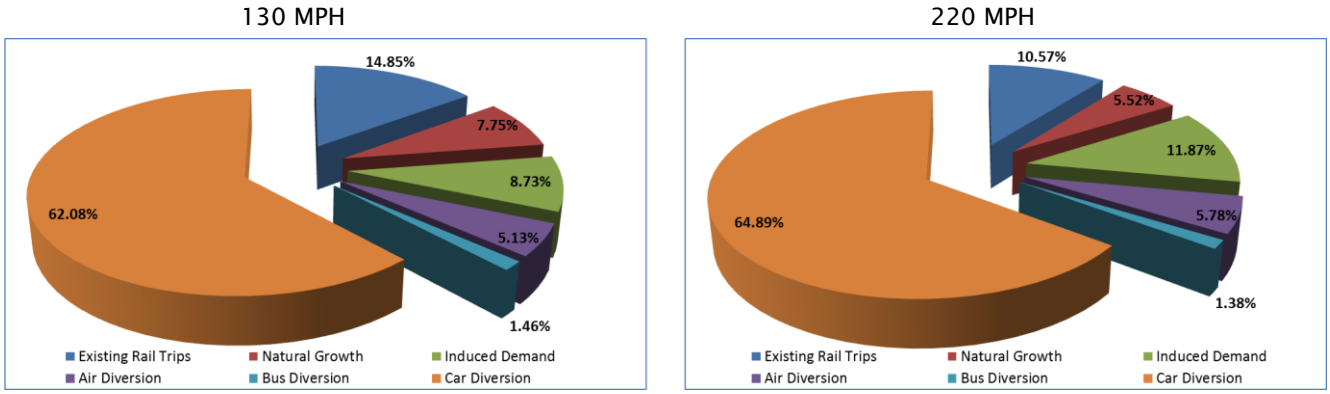
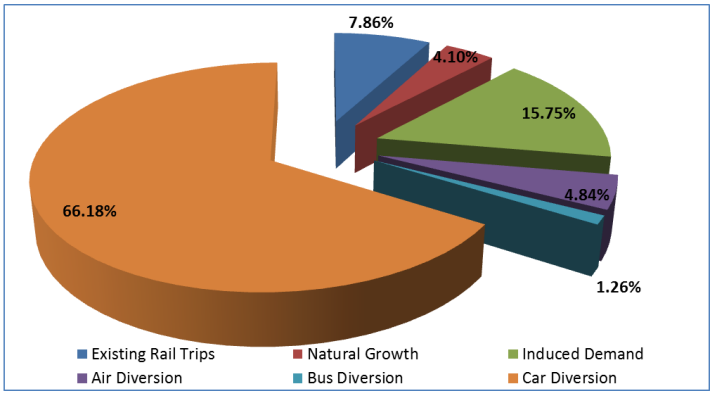


Exhibit 6-47: Sources of HSR Trips- Option 4 Richmond Direct Improved 2035



6.11 CORRIDOR TRAVEL MARKET FORECASTS BENCHMARKING

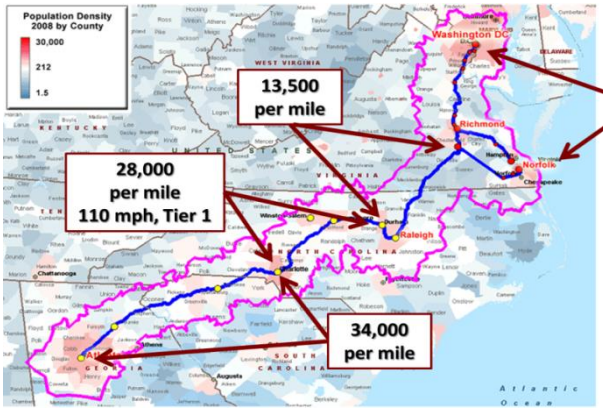
Benchmarking or making comparisons with other established rail systems/corridors is also an important factor for evaluating new rail projects. Rail projects that compare well with existing rail corridors are more likely to behave similarly and thus are likely to achieve similar success.

Exhibit 6-48 shows that the Washington-Richmond-Hampton Roads corridor has the highest population density in the SEHSR corridor, and its population density is higher than the California, Texas, Florida,, and Chicago-St. Louis corridors.

Exhibit 6-49 is a comparison of the TEMS forecast model and the DRPT FEIS model. It can be seen that by using the same rail levels-of-services as in the FEIS model, the TEMS model produces similar rail ridership and revenue forecast results.

As shown in Exhibit 6-50, the NEC NYC-DC Corridor is expected to have a rail trip rate of 18.86 to 22.19 trips per 10,000 persons per day by year 2030 and California's High Speed Ridership is expected to be about 24.27 trips, the Hampton Roads – Washington Corridor at 7.10 – 10.51 trips per 10,000 person per day by year 2030, compares well with similar sized corridors such as the Atlanta to Charlotte Corridor.

Exhibit 6-48: Washington-Richmond-Hampton Roads Corridor Population Density



National Comparison	Population Per Mile	HSR System
Northeast Corridor	74,000	220 mph
California	35,000	220 mph
Texas	48,000	220 mph
Florida	38,000	220 mph
Chicago-St. Louis	39,000	130 mph
Atlanta-Charlotte	34,000	220 mph

6-49: Comparison of Demand Forecasts to FEIS Study Option 1*

	Time	Daily Round Trips	2025 Annual Hampton Roads-Based Rail Trips (million)	2025 Annual Hampton Roads-Based Rail Revenue (million $)
DRPT FEIS* Alternative 1 90 mph	1:35	6	1.11	$73.71 ($2012)
TEMS Southern Option via Petersburg Assuming FEIS Option 1 Levels of Service	1:35	6	1.16	$76.70 ($2012)

*Richmond to Hampton Roads Passenger Rail Project, Final Environmental Impact Statement, Virginia Department of Rail and Public Transportation (DRPT), August 2012. 2008 dollars adjusted to 2012 for comparison purposes.

Exhibit 6-50: Apples-to-Apples Demand Forecast Rail Trip Rate Comparison with Other Corridors

	2030 Hampton Roads-Washington Corridor - 130 MPH[1]	2030 Atlanta-Charlotte Corridor - 130 MPH[2]	2030 Hampton Roads-Washington Corridor - 220 MPH[1]	2030 Atlanta-Charlotte Corridor – 220 MPH[2]	2030 NEC Master Plan NYC-DC Corridor (Constrained Acela)[3]	2030 NEC Next-Gen HSR NYC-DC Corridor - 220 MPH[4]	2030 California High-Speed Rail Ridership Forecast – 220 MPH[5]
Rail Trip Rate (trips per 10,000 person per day)	**7.10**	**10.30**	**10.51**	**12.06**	**18.86**	**22.19**	**24.27**

[1] Hampton Roads Passenger Rail Vision Plan Alternatives Analysis, TEMS, 2014

[2] Atlanta to Charlotte Passenger Rail Corridor EIS, Steer Davies Gleave, 2013

[3] The Northeast Corridor Infrastructure Master Plan, The NEC Master Plan Working Group, 2010

[4] The Amtrak Vision for the Northeast Corridor, Amtrak, 2012

[5] Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study, Cambridge Systematics, Inc., 2007

7. FINANCIAL AND ECONOMIC ANALYSIS

The Financial and Economic Analysis describes the USDOT FRA criteria used to assess the route and technology options. It defines the criteria and describes the process used to estimate the financial and economic benefits of the system. It provides both the financial and economic results for each option.

7.1 EVALUATION OF ALTERNATIVES

7.1.1 STUDY OBJECTIVES

This analysis uses the same criteria (updated to include Tiger Grant criteria) and structure as the 1997 FRA Commercial Feasibility Study. This study set out criteria for establishing a public-private partnership between the Federal government, State and local communities, and the private sector for intercity rail projects. The study described two conditions that were considered essential for receiving Federal funding support for proposed intercity passenger rail projects:

- An operating cost ratio of at least 1.0, defined as a pre-condition for an effective public/private partnership, so that once the system has been constructed, a private operator could operate the system on a day-to-day basis without requiring an operating subsidy, and
- A benefits/cost ratio greater than 1.0, to ensure that the project makes an overall positive contribution to the economy, at both the regional and national levels.

The Commercial Feasibility Study makes it clear that "federal consideration of specific High-Speed Ground Transportation project proposals could apply additional criteria that could differ from, and be much more stringent than, this report's threshold indicators for partnership potential."

Operating ratios are usually expressed on a year-by-year basis, but they can also be expressed as a Present Value of Revenue / Present Value of Operating Cost over the lifetime of a project.

Benefit Cost ratios are usually expressed as a Present Value of Total Benefit / Present Value of Total Cost over the lifetime of a project.

At a feasibility level of study, analysis is based on a number of assumptions that are needed to carry out the analysis. These assumptions include such factors as: rate of socioeconomic growth, rate of demographic growth, rate of energy price increase and the capital cash flows in accordance with a multi-year, implementation plan. Once more detailed assessments are made and more specific information on the rate of ridership and revenue growth and a system implementation plan detailing the capital cash flows become available, then that information can be included to further refine the initial estimates of the Financial Return and Benefit Cost ratio.

This chapter describes the process by which the alternatives were evaluated and how this analysis lead to the identification of a number of feasible options based on the economic and financial criteria adopted.

7.2 FINANCIAL AND ECONOMIC OBJECTIVES

For each alternative being evaluated, measures of financial and economic efficiency were calculated. These measures were determined from assessments integrating the forecasted capital, operating and maintenance

costs with the forecasted revenue projections over the lifetime of the project. Specifically, the analysis was based on the following components:

- Operating and implementation plans for the alternative passenger rail service options
- Cost estimates for operations, infrastructure and acquisition of rolling stock
- Ridership and revenue estimates based on projected travel demand. These forecasts include assumptions regarding fare levels and oil prices, highway congestion and the responsiveness of the air industry to the introduction of the Diesel 130-mph and Electric 220-mph Alternatives.
- Cash flow analysis that includes statements of revenues and expenses for each alternative.

Two measures, net present value (NPV) and Benefit Cost ratio were used to evaluate the economic returns of the system. Similar measures, net present value (NPV) and Operating ratio, were used to evaluate the financial returns and the potential for franchising the operations

Both measures require the development of a project's year-by-year financial and economic returns, which are then discounted to the base year to estimate present values (PV) over the lifetime of the project. For this analysis, a 25-year project life from 2030 to 2055 was assumed, with a fifteen year implementation period from 2015-2029. Revenues and cost cash flows were discounted to the 2013 base year using two discount rates: 3 percent and 7 percent. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets, and the 7 percent discount rate reflects the Federal government's desire to establish a benchmark comparison by discounting long term benefits at a greater rate than the market for public securities.

The operating ratios reported here in this chapter, follow a commercial criteria definition; but are different from the commercial operating ratio calculations that are typically presented by freight railroads and intercity bus companies. For the current analysis, the selected feasibility criteria were as follows:

- The Operating Ratio as calculated here includes direct operating costs only. The operating ratio calculations presented here do not include capital costs, depreciation or interest. The costs used are incremental costs.
- The Operating Ratio presented here is defined as Revenues/Costs. It should be noted that freight railroads and intercity bus companies typically define it as the reciprocal Costs/Revenues.

As defined by this analysis, a positive operating ratio does not imply that a passenger service can attain full financial profitability by covering its capital costs, but it does allow the operation to be franchised and operated by the private sector. The definition puts passenger rail on the same basis as other passenger transportation modes, such as intercity bus and air, where the private sector operates the system but does not build or own the infrastructure it uses. It does, however, pay access fees to the freight railroads where they own the track. In the case of passenger rail, these would include track access costs. All calculations are performed using the standard financial formula, as follows:

Financial Measure:

$$\text{Operating Ratio} = \frac{\text{Financial Revenues}}{\text{Operating Costs}}$$

Economic Measures:

Net Present Value = Present Value of Benefit – Present Values of Costs

$$\text{Benefit Cost Ratio} = \frac{\text{Present Value of Revenues}}{\text{Present Value of Costs}}$$

Present Value is defined as:

$$PV = \sum_t \frac{C_t}{(1+r)^t}$$

Where:

PV = Present value of all future cash flows

C_t = Cash flow for period t

r = Discount rate reflecting the opportunity cost of money

t = Time

In terms of Economic Benefits, a positive NPV and Benefit Cost Ratio imply that the project makes a positive contribution to the economy. For this analysis, revenues and cost cash flows were discounted to the 2013 base year using two discount rates: 3 percent and 7 percent. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets, and the 7 percent discount rate reflects the Federal government's desire to establish a benchmark comparison by discounting long term benefits at a greater rate than the market for public securities. Consistent with standard practice, Benefit Cost ratios are calculated from the perspective of the overall society without regard to who owns particular assets receives specific benefits or incurs particular costs.

7.2.1 KEY ASSUMPTIONS

The analysis projects travel demand, operating revenues and operating and maintenance costs for all years from 2030 through 2055. The financial analysis has been conducted in real terms using constant 2013 dollars. Accordingly, no inflation factor has been included and a real discounting rate of 3 to 7 percent was used. Revenues and operating costs have also been projected in constant dollars over the time frame of the financial analysis. A summary of the key efficiency measure inputs are presented below.

RIDERSHIP AND REVENUE FORECASTS

Ridership and revenue forecasts were originally prepared for 2025, 2035 and 2045. Revenues in intervening years were projected based on interpolations, reflecting projected annual growth in ridership. Revenues included not only passenger fares, but also onboard service revenues. Because of this, the revenues are slightly higher than those that were forecasted in Chapter 3.

CAPITAL COSTS

Capital costs include rolling stock, track, freight railroad right-of-way purchase or easement fees, bridges, fencing, signaling, grade crossings, maintenance facilities and station improvements. The capital cost projections are based on year-by-year projections of each cost element and include all of the capital costs, plus some selected elements of additional costs as needed to support year-by-year capacity expansion of the system. A year-by-year implementation plan was developed (as shown in Exhibit 4-10) which detailed the Capital cash flows and funding requirements. Using this information, the Benefit Cost calculations were able to be assessed.

OPERATING EXPENSES

Major operating and maintenance expenses include equipment maintenance, track and right-of-way maintenance, administration, fuel and energy, train crew and other relevant expenses. Operating expenses were estimated in 2013 constant dollars so that they would remain comparable to revenues. However, these costs do reflect the year-by-year increase in expense that is needed to handle the forecasted ridership growth, in terms of not only directly variable expenses such as credit card commissions, but also the need to add train capacity and operate either larger trains, or more train-miles every year in order to accommodate anticipated ridership growth.

Operating costs are included as a cost, whereas system revenues are included as a benefit in the discounting calculation over the life of the system. In this way they directly offset one another in the Net Present Value calculation and are also reflected in the Benefit Cost calculation. It can be seen that a system that requires an operating subsidy, e.g., where costs exceed revenues, will tend also to reflect this in the Benefit Cost ratio. This is why slow speed options such as conventional Amtrak services often fail on both the Operating Ratio and Benefit Cost ratio criteria.

IMPLEMENTATION PERIOD

According to the implementation plan, the planning and construction period for this corridor will take up to fifteen years with the start-up of full system operations not occurring until 2030. This represents a very slow and conservative planning process. If the start-up can be achieved earlier, say 2025 then both the financial and economic returns would be enhanced.

7.2.2 ESTIMATE OF ECONOMIC BENEFITS

A key requirement is the need for public capital investment to be supported by the economic benefit that will be generated by the rail system. Calculation of the economic benefit includes both consumer surplus and revenues generated by the system and environmental and external mode benefits; while costs include both capital and operating costs. Similar to the way most highway projects are justified, the primary justification for intercity rail projects relies on time savings multiplied by the user's value of time. The consumer surplus term equates to the passenger user's value of time savings as being the benefit an individual receives over and above the fare charged for using the system.

Calculation of benefit cost ratios requires a detailed, year-by-year forecast to support the calculation of Net Present Values for all the costs and benefits associated with the project. Specifically, a year-by-year estimate of system revenues, consumer surplus, operating costs, capital costs, and external benefits is needed to develop the Benefit Cost Analysis.

In line with Federal, State and Municipal projections, the rate of population growth, the increasing price of oil, and the increasing congestion on Virginian highways (e.g., I-95, I-64), means that there is a gradual increase in rail users over the life of the project. This has several consequences for the correct calculation of Benefit/Cost ratios for the project –

- It would be inappropriate to increase the ridership and revenue of the system in future years, without also reflecting the added operating and capital costs that will be needed to accommodate this growth in traffic.
- The result is a steady improvement in the system financial performance that reflects improved economies of scale over the 30-year life of the system. While the Benefit Cost ratios calculated do take this forecast growth into account, they also add the additional capital cost for providing the capacity needed to handle it. The economic benefits to be used in the analysis include two main categories:
  - User Benefits (Consumer Surplus)
  - Other Mode and Resource Benefits

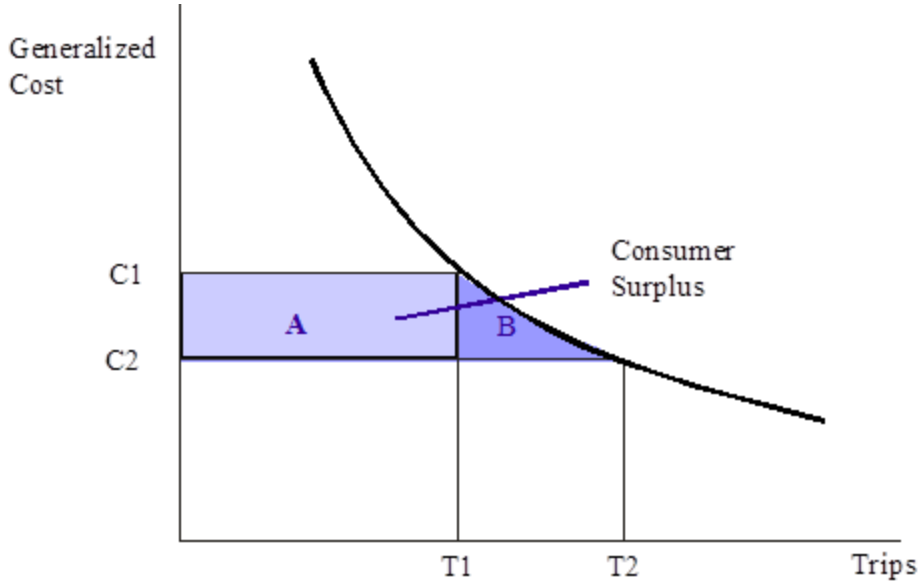
USER BENEFITS

The analysis of user benefits for this study is based on the measurement of Generalized Cost of Travel, which includes both time and money. Time is converted into money by the use of Values of Time. The Values of Time (VOT) used in this study were derived from stated preference surveys conducted in previous study phases of work and used in the COMPASS™ multimodal demand model for the ridership and revenue forecasts. These VOTs are consistent with previous academic and empirical research and other transportation studies conducted by TEMS.

Benefits to users of the rail system are measured by the sum of system revenues and consumer surplus. Consumer surplus is used to measure the demand side impact of a transportation improvement on users of the service. It is defined as the additional benefit consumers (users of the service) receive from the purchase of a commodity or service (travel), above the price actually paid for that commodity or service. Consumer surpluses exist because there are always consumers who are willing to pay a higher price than that actually charged for the commodity or service, i.e., these consumers receive more benefit than is reflected by the system revenues alone. Revenues are included in the measure of consumer surplus as a proxy measure for the consumer surplus forgone because the price of rail service is not zero. This is an equity decision made by the USDOT to compensate for the fact that highway users pay zero for use of the road system (the only exception being the use of toll roads). The benefits apply to existing rail travelers as well as new travelers who are induced (those who previously did not make a trip) or diverted (those who previously used a different mode) to the new passenger rail system.

The RENTS™ financial and economic analysis estimates passenger travel benefits (consumer surplus) by calculating the increase in regional mobility, traffic diverted to rail, and the reduction in travel cost measured in terms of generalized cost for existing rail users. The term generalized cost refers to the combination of time and fares paid by users to make a trip. A reduction in generalized cost generates an increase in the passenger rail user benefits. A transportation improvement that leads to improved mobility reduces the generalized cost of travel, which in turn leads to an increase in consumer surplus. Exhibit 7-1 presents a typical demand curve in which Area A represents the increase in consumer surplus resulting from cost savings for existing rail users and Area B represents the consumer surplus resulting from induced traffic and trips diverted to rail.

Exhibit 7-1: Consumer Surplus Concept



The formula for consumer surplus is as follows –

Consumer Surplus = $(C_1 - C_2)*T1 + ((C_1 - C_2)*(T_2 - T_1))/2$

Where:

C_1 = Generalized Cost users incur before the implementation of the system

C_2 = Generalized Cost users incur after the implementation of the system

T_1 = Number of trips before operation of the system

T_2 = Number of trips during operation of the system

The passenger rail fares used in this analysis are the average optimal fares derived from the revenue-maximization analysis that was performed for each alternative. User benefits incorporate the measured consumer surplus, as well as the system revenues, since these are benefits are merely transferred from the rail user to the rail operator.

OTHER MODE BENEFITS

Other Mode and Resource Benefits: In addition to rail-user benefits, travelers using auto or air will also benefit from the rail investment, since the system will contribute to highway congestion relief and reduce travel times for users of these other modes. For purposes of this analysis, these benefits were measured by identifying the estimated number of auto passenger trips diverted to rail and multiplying each by the updated monetary values derived from previous stated preference studies updated to 2013.

Highway Congestion: The highway congestion delay savings is the time savings to the remaining highway users that results from diversion of auto users to the rail mode. To estimate travel time increase within the corridor, historical highway traffic volumes were obtained from the State DOTs and local planning agencies. The average annual travel time growth in the corridor was estimated with the historical highway traffic volume data and the BPR (Bureau of Public Roads) function that can be used to calculate travel time growth with increased traffic volumes.

The Airport Congestion Delay Savings: The Airport Congestion Delay Savings were based 1997 FRA Commercial Feasibility Study and updated to 2013 value. The Airport Congestion Delay Savings includes the airport operation delay saving and air passenger delay saving.

Auto Operating Cost (Non Business): Vehicle operating cost savings for non-business travelers have been included in the current analysis as an additional resource benefit. This reflects the fact that social/leisure travelers do not accurately value the full cost of driving when making trips. As a result, the consumer surplus calculation for commuters, social, leisure and tourist travelers has not fully reflected the real cost of operations of an automobile, but only the cost of gas. The difference between the cost of gas and the full cost of driving reflects a real savings that should be included in a Benefit Cost analysis.

Emissions: The diversion of travelers to rail from the auto mode generates emissions savings. The calculated emissions savings are based on changes in energy use with and without the proposed rail service. This methodology takes into account the region of the country, air quality regulation compliance of the counties served by the proposed rail service, the projection year, and the modes of travel used for access/egress as well as the line-haul portion of the trip. Highway Reduced Emissions were estimated from the vehicle miles traveled (VMT) and flight reductions derived from the ridership model. The assumption is that a reduction in VMT or flights is directly proportional to the reduction in emissions. The pollutant values were taken from the latest TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide[1].

Public Safety Benefits: Public Safety is calculated from the diverted Vehicle-Miles times the NHTSA[2] fatality and injury rate per Vehicle mile and then times the values of fatality and injury from the latest TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide[1]. This was calculated for 2025, 2035 and 2045 then interpolated or extrapolated for all other years.

7.3 FINANCIAL RESULTS

The financial evaluation was completed for all route options (1, 2, 3 and 4) that are being assessed in the Route Analysis. Options 1 and 2 each included two route variants and two technology options for each route, reflecting different access routes into Richmond and are defined as sub-options. Specifically, the five sub-options are as follows:

- Southern Option 1A – Greenfield via Petersburg
- Southern Option 1B – Norfolk Southern (NS) via Petersburg
- Northern Option 2A – Greenfield via Hopewell
- Northern Option 2B – Norfolk Southern (NS) via Hopewell
- Option 3 – Richmond Direct
- Option 4 - Richmond Direct Improved (Option 3 w/Peninsula Service added)

For Options 1, 2 and 3, two technology options were developed for the 130-mph diesel technology, and the 220-mph electric technology. Option 4 is defined as a combination of diesel and electric technology so only Financial and Economic evaluation needed to be performed for that option.

The Financial Analysis methodology followed typical financial cash flow analysis and USDOT-Tiger Grant guidelines, as well as OMB discount procedures for the economic analysis. There are two key operating financial performance factors for the system, which are the key drivers of the financial evaluation:

[1] http://www.dot.gov/sites/dot.dev/files/docs/TIGER_BCA_RESOURCE_GUIDE.pdf
[2] http://www.nhtsa.gov/

- **System Revenues:** These include the fare box revenues and revenues from onboard sales. Revenues were derived from the Ridership and Revenue Analysis.
- **Operating Costs:** These are the operating and maintenance costs associated with running the train schedules and include onboard service costs. The operating costs for the system were developed using the methodology.

The **Operating Surplus**, which is defined as Revenues minus Operating Cost, is a critical factor in the overall business case as it determines the ability to franchise the operation.

- **If the operating surplus is positive**, the system will not require any operating subsidy, and it will even be able to make a contribution towards its own Capital cost, as the Northeast Corridor does today. In addition because the system is generating a positive cash flow, a Private-Public Partnership or other innovative financing methods can be used to construct and operate the system. This absolves the local entity of any need for providing an operating subsidy but more than this, it is not uncommon for the operating cash flow to be sufficient to cover the local match requirement as well.
- **If the operating surplus is negative**, the system will not only require a grant of capital to build the system, but in addition it will also require an ongoing operating subsidy. An operating subsidy not only prevents the project from being a Public Private Partnership, but casts doubt on the efficiency of the system and the reason for the project. In addition, a subsidy will reduce the economic performance of the system as it will actually offset part of the economic benefits of the system (e.g. Consumer Surplus, Environmental Benefits). This will depress the Benefit Cost ratio. If the subsidy is not too great and the capital cost is not too high, in some cases it may still be possible to maintain a positive Benefit Cost ratio. But the larger the subsidy and the higher the capital cost, the harder it is to show a positive Benefit Cost ratio. It is not uncommon for passenger rail systems that operate slower than 100-mph[3] to fail both FRA's Operating Ratio and Benefit Cost criteria.

7.3.1 OPERATING RATIOS

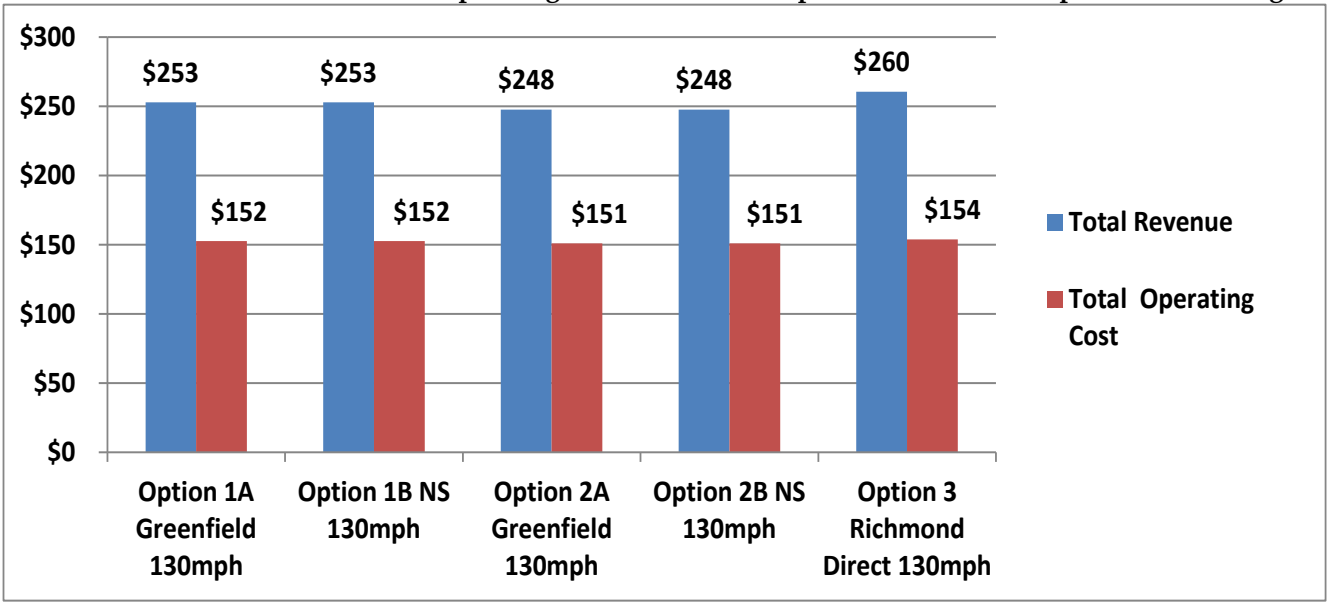
Exhibit 7-2 shows the revenues, operating costs and operating ratios for each route option variant for year 2035. Exhibit 7-3 displays bar charts that compare 2035 revenues and operating costs for 130-mph vs 220-mph technology options.

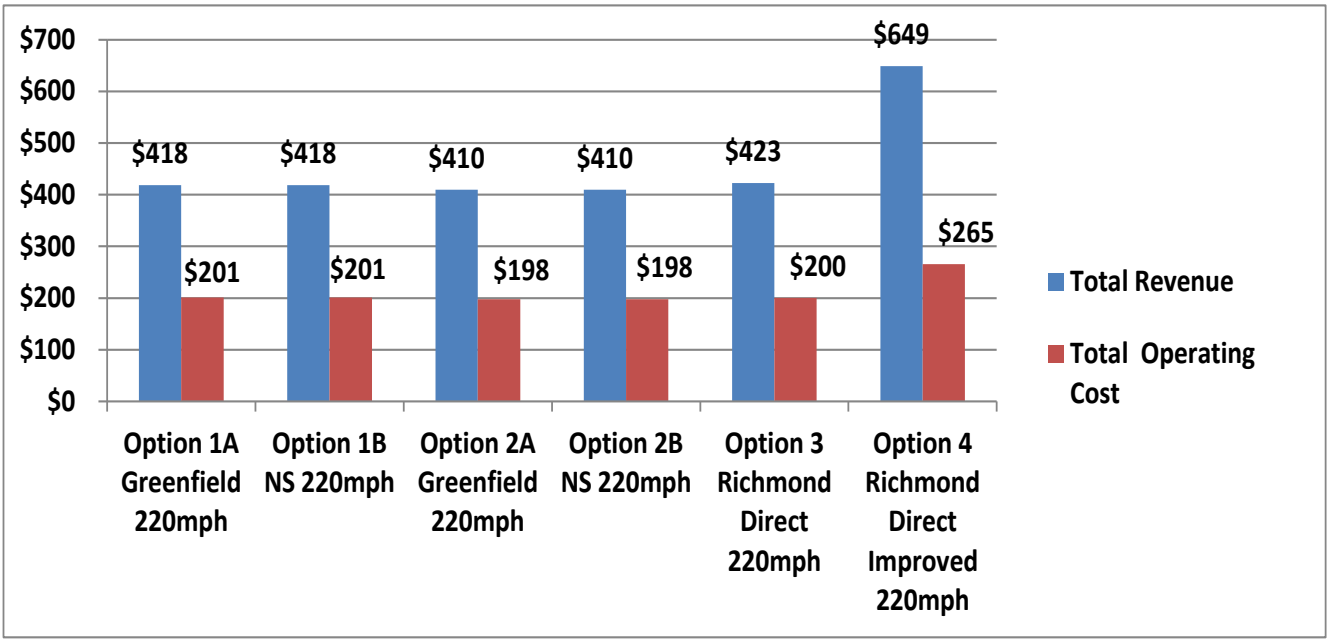
[3] *Atlanta-Charlotte Tier I EIS*, in publication, and *Cost-Benefit Analysis of Washington-Richmond High-Speed Rail*, George Mason University for Amtrak, May 14, 2010. See: http://policy.gmu.edu/wp-content/uploads/Cost_Benefit_Analysis_of_Washington_Richmond_High_Speed_Rail.pdf

Exhibit 7-2: Years 2035 Revenues and Operating Ratios for all HRTPO Rail Options

Financial 2035 (mill. 2013$)	Southern Option 1 Via Petersburg				Northern Option 2 -Via Hopewell				Option 3 Richmond Direct		Option 4 Richmond Direct Improved
	Southern Option 1A Greenfield		Southern Option 1B Norfolk Southern		Northern Option 2A Greenfield		Northern Option 2B Norfolk Southern				
	130mph	220mph	130mph	220mph	130mph	220mph	130mph	220mph	130mph	220mph	220mph
Revenue											
Ticket Revenue	$233.97	$387.38	$233.97	$387.38	$229.19	$379.49	$229.19	$379.49	$241.19	$391.26	$600.48
OBS Revenue 8%	$18.72	$30.99	$18.72	$30.99	$18.33	$30.36	$18.33	$30.36	$19.30	$31.30	$48.04
Total Revenue	**$252.68**	**$418.37**	**$252.68**	**$418.37**	**$247.52**	**$409.85**	**$247.52**	**$409.85**	**$260.49**	**$422.56**	**$648.52**
COSTS											
Train Crew	$12.85	$18.16	$12.85	$18.16	$12.70	$17.78	$12.70	$17.78	$13.05	$18.19	$24.71
OBS	$16.04	$25.01	$16.04	$25.01	$15.77	$24.50	$15.77	$24.50	$16.44	$25.18	$36.97
Equipment	$33.16	$55.58	$33.16	$55.58	$32.78	$54.43	$32.78	$54.43	$33.69	$55.67	$75.64
Fuel	$24.36	$10.66	$24.36	$10.66	$24.08	$10.44	$24.08	$10.44	$24.75	$10.67	$14.51
Track	$11.95	$23.45	$11.95	$23.45	$11.78	$23.12	$11.78	$23.12	$11.56	$22.68	$25.47
Insurance	$8.77	$13.26	$8.77	$13.26	$8.67	$12.99	$8.67	$12.99	$8.91	$13.28	$18.05
Call Ctr Variable	$3.13	$4.43	$3.13	$4.43	$3.09	$4.33	$3.09	$4.33	$3.26	$4.58	$6.16
T-Agent and CC Comm	$6.55	$10.85	$6.55	$10.85	$6.42	$10.63	$6.42	$10.63	$6.75	$10.96	$16.81
Stations	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$5.91	$5.91	$6.98
Admin and Mgt	$19.15	$21.61	$19.15	$21.61	$19.10	$21.46	$19.10	$21.46	$19.23	$21.62	$24.24
Operation & Dispatch	$1.09	$1.70	$1.09	$1.70	$1.07	$1.67	$1.07	$1.67	$1.05	$1.64	$2.61
Operator Profit 10% selected items	$8.96	$9.89	$8.96	$9.89	$8.87	$9.73	$8.87	$9.73	$9.05	$9.87	$13.30
Total Cost	**$152.46**	**$201.03**	**$152.46**	**$201.03**	**$150.78**	**$197.52**	**$150.78**	**$197.52**	**$153.66**	**$200.25**	**$265.45**
Operating Surplus	**$100.23**	**$217.34**	**$100.23**	**$217.34**	**$96.74**	**$212.33**	**$96.74**	**$212.33**	**$106.82**	**$222.31**	**$383.06**
Operating Ratio	**1.66**	**2.08**	**1.66**	**2.08**	**1.64**	**2.07**	**1.64**	**2.07**	**1.70**	**2.11**	**2.44**

Exhibit 7-3: Year 2035 Revenues vs Operating Costs Diesel 130-mph and Electric 220-mph Rail Technologies





It can be seen that all route variants have positive operating surpluses and positive operating ratios in year 2035, with the Electric 220-mph options having better results due to higher ridership and revenues despite the higher operating costs. The results of this analysis also show that all of the proposed route options are franchisable with a positive cash flow that is greater than the system operating costs.

Option 3, the Richmond Direct route using 220-mph technology, is seen to have slightly better cash flows than the other options, although they are all very comparable to each other. However, the best option by far is seen to the Option 4 which adds a diesel service at 130-mph on top of the Option 3 Richmond direct 220-mph electric service. Adding rail service to the Peninsula as well as the Southside in Option 4 substantially boosts the revenue and ridership potential of the overall system.

7.4 ECONOMIC RESULTS

The Demandside Economic Analysis was completed using data derived from the Ridership and Revenue Analysis, the Infrastructure Analysis, and the Operating Analysis. This provided:

- **System Revenues -** Fare box and onboard revenue
- **Operating Costs** - Operating and maintenance costs
- **Capital costs** - Infrastructure costs

In addition, the Economic benefits of the system to be assessed for the analysis include –

- **Consumer Surplus** – benefit to system users
- **Revenues**
- **Highway Congestion Savings** – benefits to road users of less congestion
- **Airport Delay Savings** – benefits to air travelers
- **Safety Benefits** – benefit of less accidents
- **Reduced Emissions** – benefit of lower emissions levels
- **Highway Resource Savings**

7.4.1 COST BENEFIT RATIOS AND NET PRESENT VALUE

The economic results for all options and technology variants are shown in exhibit 7-4. The exhibit shows the NPV break down of benefits, costs and the resulting Benefit/Cost ratio at the 3% and 7% discount rates. Exhibit 7-5 graphically compares the total benefits vs total costs for each of the route technology options at 3% and 7% discount rates.

Exhibit 7-4: Comparing the Benefit-Cost and NPV Surplus results at the 3% and 7% Discount rates for all route and technology variants

Southern Option 1 - Via Petersburg

	3% Discount				7% Discount			
million $	Option 1A Greenfield 130mph	Option 1A Greenfield 220mph	Option1B NS 130mph	Option1B NS 220mph	Option 1A Greenfield 130mph	Option 1A Greenfield 220mph	Option1B NS 130mph	Option1B NS 220mph
System Passenger Revenues	$2,844	$4,673	$2,844	$4,673	$945	$1,563	$945	$1,563
OBS	$228	$374	$228	$374	$76	$125	$76	$125
Users Consumer Surplus	$2,248	$2,805	$2,248	$2,805	$760	$949	$760	$949
Highway Congestion Savings	$1,668	$2,381	$1,668	$2,381	$536	$769	$536	$769
Airport Delay Saving	$265	$418	$265	$418	$86	$135	$86	$135
Safety Benefits	$506	$799	$506	$799	$170	$269	$170	$269
Highway Reduced Emissions	$112	$177	$112	$177	$37	$59	$37	$59
Total Benefits	**$7,871**	**$11,626**	**$7,871**	**$11,626**	**$2,610**	**$3,870**	**$2,610**	**$3,870**
Capital Cost	$3,713	$5,136	$3,686	$5,099	$2,094	$2,897	$2,079	$2,876
O&M Costs	$1,820	$2,366	$1,820	$2,366	$609	$798	$609	$798
Cyclic Mtn	$65	$65	$65	$65	$18	$18	$18	$18
Total Costs	**$5,598**	**$7,567**	**$5,571**	**$7,530**	**$2,721**	**$3,713**	**$2,706**	**$3,692**
NPV(Surplus)	**$2,273**	**$4,059**	**$2,300**	**$4,096**	**($110)**	**$158**	**($95)**	**$178**
Benefit/Cost Ratio	**1.41**	**1.54**	**1.41**	**1.54**	**0.96**	**1.04**	**0.96**	**1.05**

Exhibit 7-4: Comparing the Benefit-Cost and NPV Surplus results at the 3% and 7% Discount rates for all route and technology variants (cont)

Northern Option 2 - Via Hopewell

	3% Discount				7% Discount			
million $	Option 2A Greenfield 130mph	Option 2A Greenfield 220mph	Option 2B NS 130mph	Option 2B NS 220mph	Option 2A Greenfield 130mph	Option 2A Greenfield 220mph	Option 2B NS 130mph	Option 2B NS 220mph
System Passenger Revenues	$2,786	$4,583	$2,786	$4,583	$926	$1,531	$926	$1,531
OBS	$223	$367	$223	$367	$74	$122	$74	$122
Users Consumer Surplus	$2,224	$2,732	$2,224	$2,732	$753	$924	$753	$924
Highway Congestion Savings	$1,652	$2,344	$1,652	$2,344	$531	$757	$531	$757
Airport Delay Saving	$263	$376	$263	$376	$86	$122	$86	$122
Safety Benefits	$498	$788	$498	$788	$167	$265	$167	$265
Highway Reduced Emissions	$111	$175	$111	$175	$36	$58	$36	$58
Total Benefits	**$7,757**	**$11,364**	**$7,757**	**$11,364**	**$2,573**	**$3,780**	**$2,573**	**$3,780**
Capital Cost	$3,714	$5,137	$3,674	$5,082	$2,095	$2,897	$2,072	$2,867
O&M Costs	$1,800	$2,327	$1,800	$2,327	$602	$784	$602	$784
Cyclic Mtn	$64	$64	$64	$64	$18	$18	$18	$18
Total Costs	**$5,578**	**$7,528**	**$5,538**	**$7,473**	**$2,714**	**$3,699**	**$2,692**	**$3,668**
NPV(Surplus)	**$2,180**	**$3,836**	**$2,219**	**$3,891**	**($141)**	**$81**	**($119)**	**$111**
Benefit/Cost Ratio	**1.39**	**1.51**	**1.40**	**1.52**	**0.95**	**1.02**	**0.96**	**1.03**

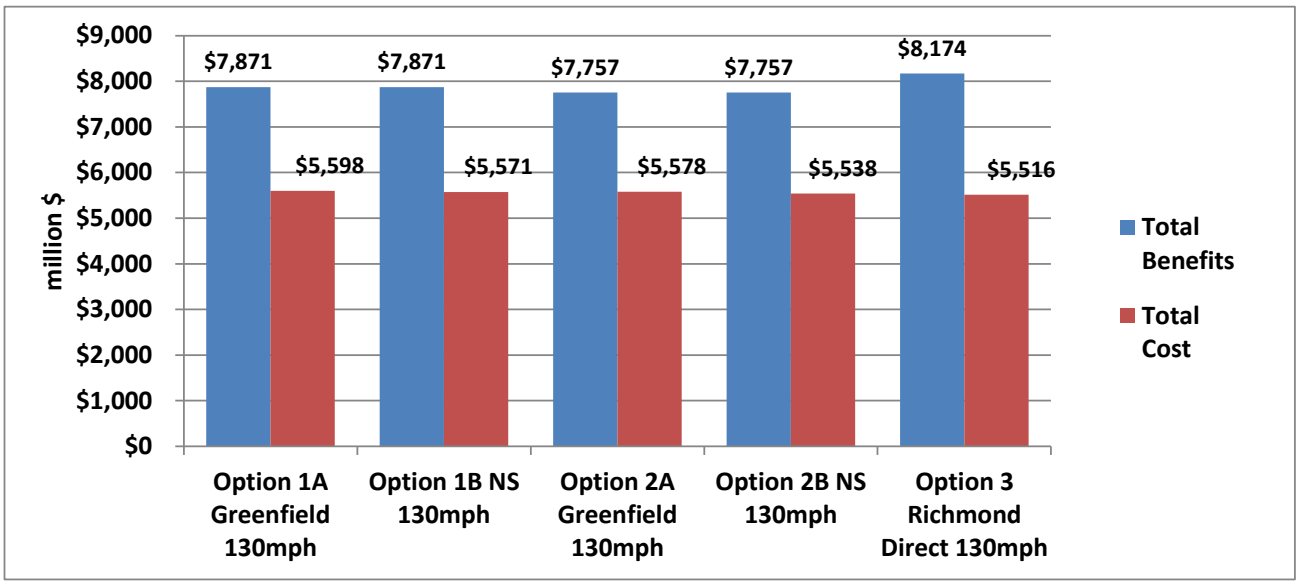
Exhibit 7-4: Comparing the Benefit-Cost and NPV Surplus results at the 3% and 7% Discount rates for all route and technology variants (cont)

Richmond Direct Options 3 and 4

million $	3%			7%		
	Option 3 Richmond Direct 130mph	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improved 220mph	Option 3 Richmond Direct 130mph	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improved 220mph
System Passenger Revenues	$2,925	$4,718	$7,142	$974	$1,578	$2,399
OBS	$234	$377	$571	$78	$126	$192
Users Consumer Surplus	$2,326	$2,920	$5,870	$787	$987	$1,990
Highway Congestion Savings	$1,790	$2,454	$2,934	$576	$794	$952
Airport Delay Saving	$267	$424	$479	$87	$137	$155
Safety Benefits	$517	$801	$1,101	$173	$270	$372
Highway Reduced Emissions	$115	$178	$244	$38	$59	$81
Total Benefits	**$8,174**	**$11,872**	**$18,340**	**$2,714**	**$3,952**	**$6,140**
Capital Cost	$3,622	$5,010	$5,737	$2,043	$2,826	$3,236
O&M Costs	$1,832	$2,357	$3,116	$613	$795	$1,054
Cyclic Mtn	$63	$63	$78	$17	$17	$22
Total Costs	**$5,516**	**$7,429**	**$8,931**	**$2,673**	**$3,638**	**$4,311**
NPV(Surplus)	**$2,658**	**$4,443**	**$9,409**	**$40**	**$314**	**$1,829**
Benefit/Cost Ratio	**1.48**	**1.60**	**2.05**	**1.02**	**1.09**	**1.42**

Exhibit 7-5: Comparing the total benefits vs costs for each of the route technology options at 3% and 7% discount rates

Diesel 130 mph Technology Options at 3% Discount Rate



Electric 220 mph Technology Options at 3% Discount Rate

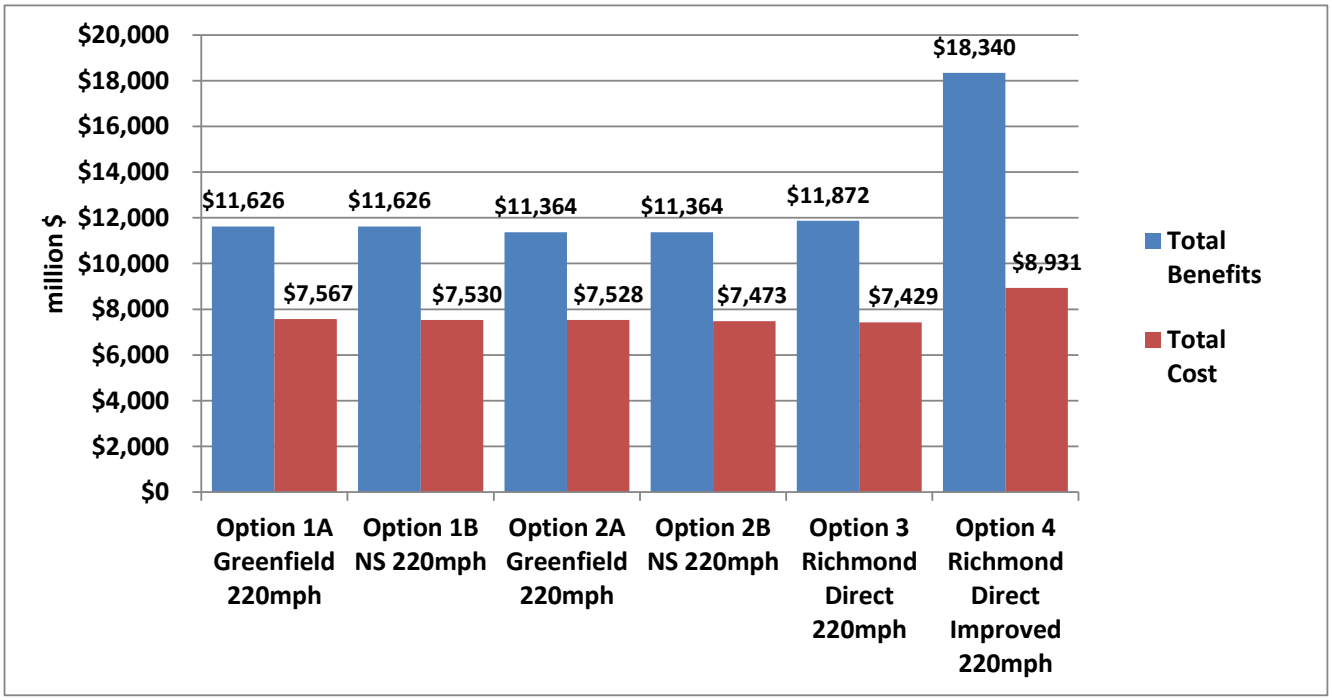
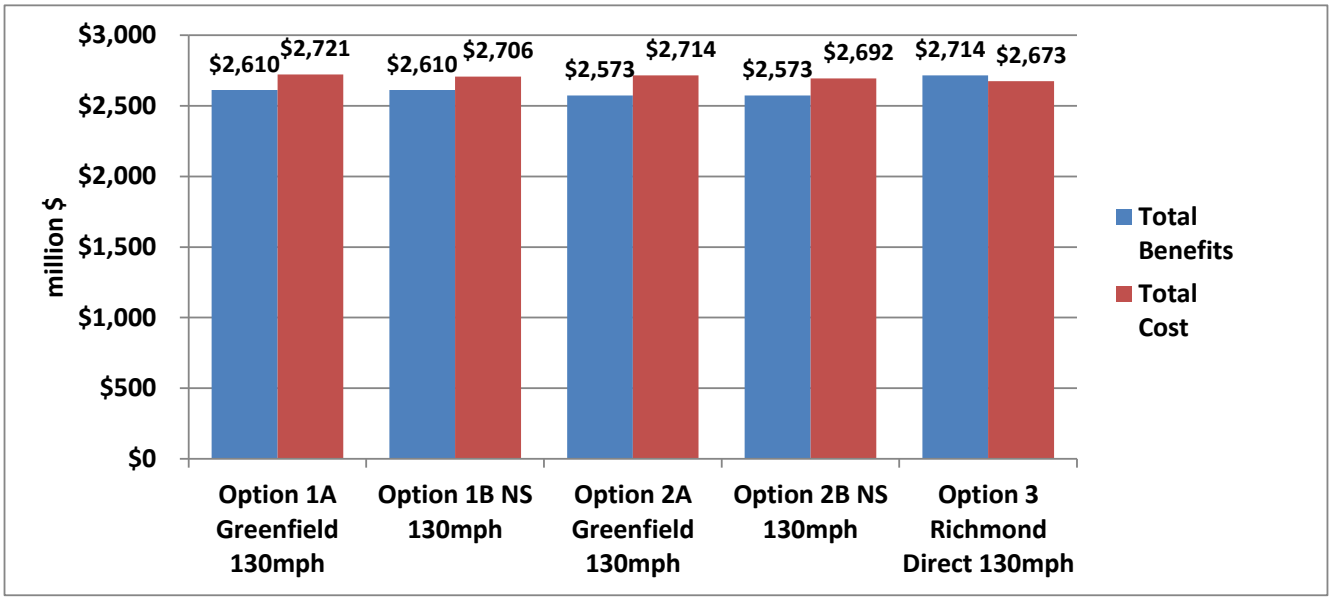
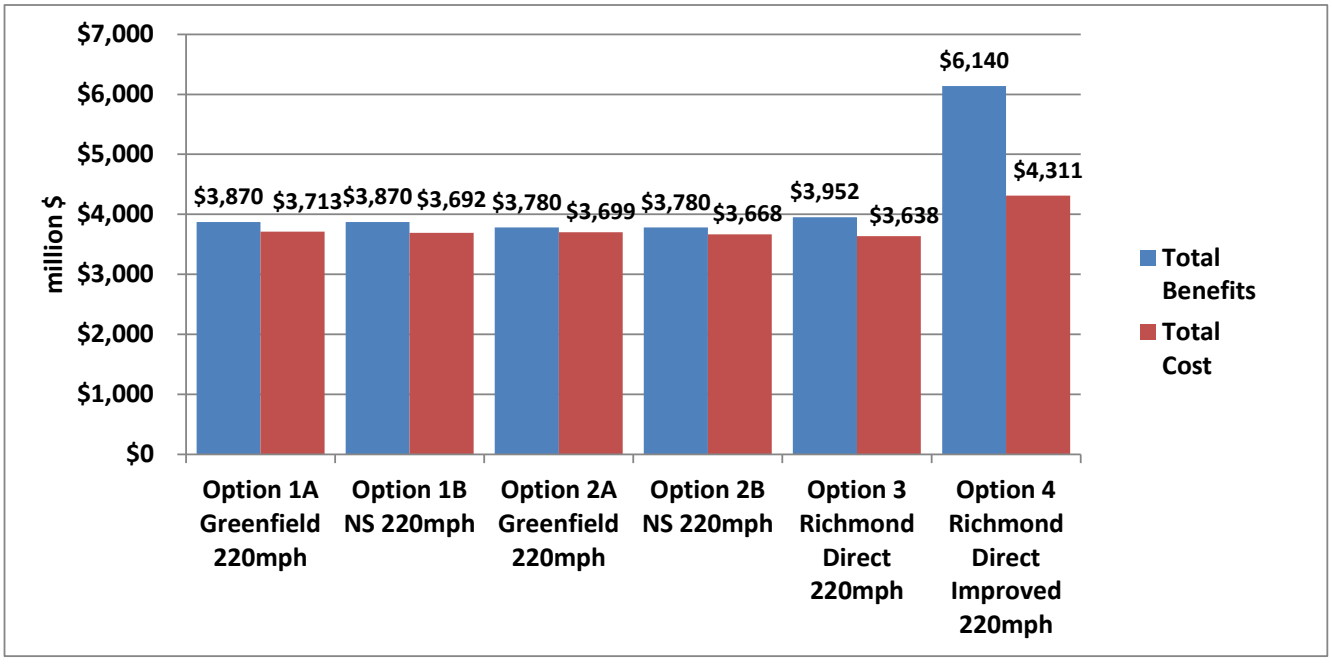


Exhibit 7-5: Comparing the total benefits vs costs for each of the route technology options at 3% and 7% discount rates (cont)

Diesel 130-mph Technology Options at 7% Discount Rate



Electric 220-mph Technology Options at 7% Discount Rate



This analysis begins by performing an apples-to-apples comparison of the five Norfolk-Washington D.C. route options 1A, 1B, 2A, 2B and 3:

- As can be seen in the exhibits, all route options show positive benefit/cost ratios with Option 3 (Richmond Direct) using 220-mph technology showing the best results of all the Norfolk-Washington D.C. options at the 3% discount level (B/C: 1.60). However, all Norfolk-Washington D.C. options have results that are comparable to each other at both the 3% and 7% discount rates. Also, all route options using the 220-mph electric train technology have better financial results vs the options that use 130-mph diesel technology, although with much lower gains at the 7% discount rates. NPV Surpluses, in particular, are higher for all route options using the 220-mph electric technology with surpluses being much greater at the 3% discount rate vs the 7% discount rate. In fact, 130-mph technology Norfolk-Washington D.C. options 1A, 1B, 2A and 2B have negative NPV values at the 7% discount rate. NPV surpluses for the 220-mph technology options are greater despite their higher costs due to the increases in ridership and overall benefits that using a more efficient higher speed rail technology would bring. In conclusion, the results show that all Norfolk-Washington D.C. options and technology variants are viable at the 3% discount rate; however, only Option 3 Richmond Direct remains viable at the 7% discount rate for all technology variants.
- Based on these results, the most viable route option for Norfolk-Washington D.C. is found to be Option 3 Richmond Direct using electric 220-mph train technology. For this option an initial 130-mph implementation step is even possible given that 130-mph technology is viable at a 7% discount rate.

Based on this finding that Option 3 Richmond Direct gave the best standalone result for Norfolk-Washington D.C., an additional Option 4 Richmond Direct Improved was developed by noting that a substantial portion of this same alignment could also potentially be shared by a Peninsula rail service.

Adding a Peninsula rail service makes Option 4 clearly stand above all the others. It is clear that adding additional ridership and revenue from the Peninsula significantly enhances the economics of the overall Hampton Roads – Richmond – Washington D.C. rail corridor. The most significant metric is the Cost Benefit ratio at 7% which jumps from 1.09 for Option 3 up to 1.42 for Option 4.

Given the fact that the 7% discount rate is actually a capital rationing rate, the ability to project a 1.42 Cost Benefit ratio at such a high interest rate shows that development of the Hampton Roads – Richmond – Washington D.C. corridor including Peninsula rail service is truly an outstanding project. It implementation would strongly benefit Hampton Roads, Virginia and the US economy as a whole.

7.5 BENCHMARKING COMPARISONS

Benchmarking comparisons have been developed to put the current study results into context of the findings of other studies. The comparison divides projects into three groups:

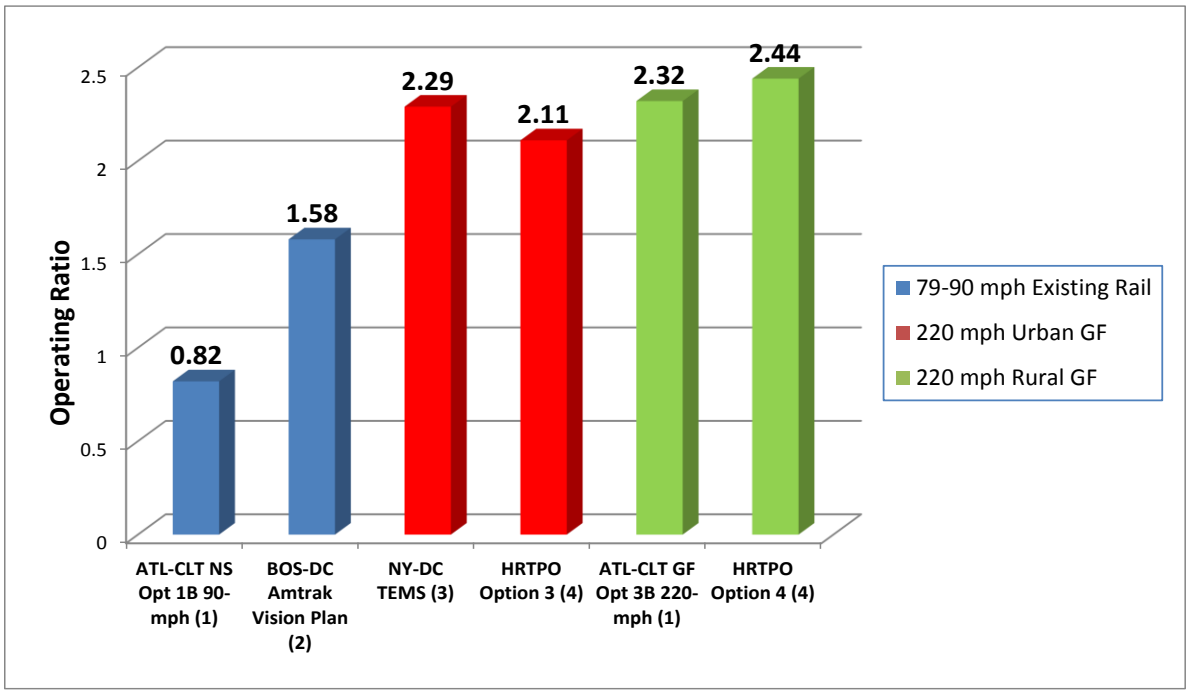
(1) **Projects based on upgrading existing rail lines at 79-90 mph.** These tend to be rail lines where, although the underlying market may be strong, train speeds are severely limited due to geometric considerations. As a result these projects have difficulty in producing travel times that are auto competitive.

(2) **NEC Projects based on extensive use of Urban Greenfield.** These projects typically entail massive bridging and tunneling, e.g. long urban tunnels (such as under Baltimore, Philadelphia and New York) and often underwater tunnels (e.g. Hudson and East Rivers) at double to triple the cost of normal tunnels. California High Speed rail also has some segments of urban greenfield which add considerably to its cost.

(3) **National Projects based on extensive use of Rural Greenfield.** High Speed rail can be economical in corridors that are less dense than the NEC, if costs can be kept in proportion to the ridership forecast. Typically this is done by maximizing the use of greenfields in rural areas where construction is relatively economical, but avoiding the use of urban greenfield where costs can be an order of magnitude higher.

As shown in Exhibit 7-6, projects in the low speed range tend to have negative operating ratios <1.0 (e.g. require operating subsidies) whereas faster speeds make the service a lot more attractive to riders allows high enough fares to be charged so the need for operating subsidies can be eliminated. Typically 220-mph High Speed rail systems produce operating ratios in the 2.0-3.0 range spinning off substantial positive cash flows that can cover at least of portion of the system's capital cost.

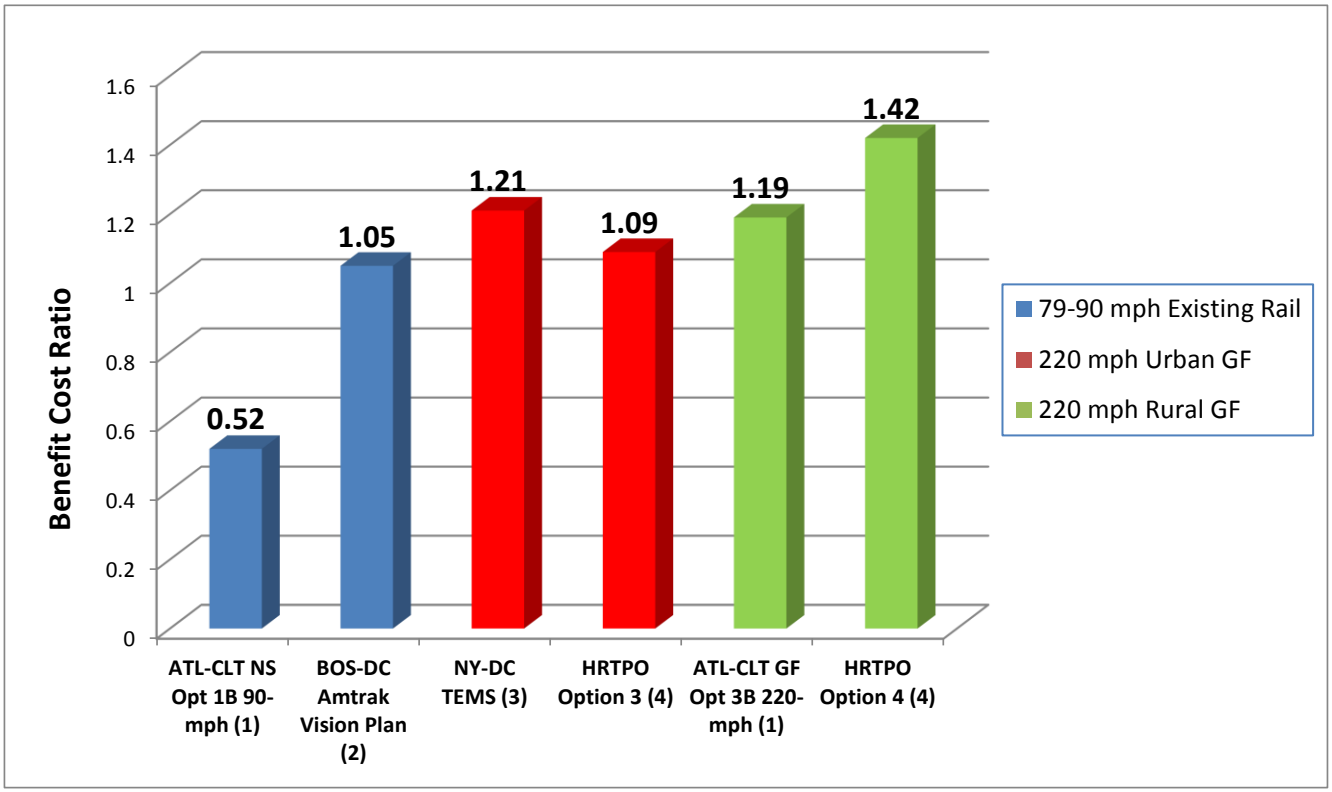
Exhibit 7-6: Benchmarking on Operating Ratio Results



In Exhibit 7-6, the Amtrak Vision Plan result (although strongly positive) is a little lower than TEMS since it includes regional operations over existing tracks all the way to Boston, as well as some corridor extensions (e.g. Springfield and Harrisburg). The TEMS result is only for the core New York to Washington High Speed spine and is based on a moderate fare that is intended to promote the broad market applicability of the service, rather than the narrow market extremely high fare focus of Amtrak's current Acela service. This NEC moderate fare assumption would produce operating results that are very similar to the proposed Hampton Roads service. If an Acela-level average fare continued to be applied, the NEC operating ratio results would be better than shown, but the Cost Benefit results would be depressed undermining the case for public investment in the infrastructure. The moderate fare scenario as proposed is more socially beneficial and since the fare is lower, it would result in a higher ridership and better Cost Benefit result. The moderate fare scenario would require however, more capital contribution from the Public sector than the high fare scenario.

Regarding the Cost Benefit results shown in Exhibit 7-7, a key finding is that results for low speed intercity services tend to be negative, as was found to be the case for upgrades to the Atlanta-Charlotte[4] existing NS rail line. These projects tend to produce negative cost benefit ratios <1.0. A handful of very inexpensive projects for upgrading light density branch lines have been seen to produce positive cost benefit ratios >1.0 but they still have negative operating ratios < 1.0 (e.g. require operating subsidies.) However given the high costs for adding capacity to major mainline freight routes, and the operating restrictions and service reliability impacts that tend to go along with those kinds of strategies, negative economic results tend to be the norm for these kinds of projects.

Exhibit 7-7: Benchmarking on Cost Benefit Results



[4] Reference (1) in Exhibit 7-7: Atlanta-Charlotte Tier I EIS, in publication

Regarding Cost Benefit results for High Speed rail, it should be noted that the cost for Urban Greenfield is much higher than that for Rural Greenfield development. While rural greenfield typically costs $30-40 million a mile for a double track section, urban tunnels can cost $300 million a mile and underwater tunnels $1 billion a mile. The cost of these extensive bridges and tunnels can be seen Amtrak's average cost of $274 million per mile[5] for NEC improvements[6] all the way to Boston. These include major tunnels under Baltimore, Philadelphia and New York City.[7] Nonetheless it is interesting to note that even with such high costs Amtrak has projected a positive Cost Benefit ratio (1.05 at 7%) for this investment.

This classic European approach to development of High Speed rail is to limit development of greenfields to rural areas to keep the cost down, and use existing rail lines to gain access to the urban cores. In development of High Speed Rail options for Hampton Roads TEMS has followed the classic European approach, intentionally seeking to avoid the kinds of massive bridging and tunneling that have been proposed for the NEC north of Washington, D.C. By doing this, it is possible to hold costs to affordable and economically justifiable levels.

As a result, in terms of Cost Benefit results for High Speed proposals that are primarily based on rural Greenfields, these are seen to be just as satisfactory if not more so than the higher density, but much more expensive corridor investments such as the NEC. This is not to say that such approaches are not necessary or justified for the NEC. But the key in every case is to appropriately match the infrastructure to market demand, as has been done in development of this High Speed Rail plan for Hampton Roads.

[5] Reference (2) in Exhibit 7-7: *A Vision for High-Speed Rail in the Northeast Corridor*, Amtrak, September 2010.
http://www.amtrak.com/ccurl/214/393/A-Vision-for-High-Speed-Rail-in-the-Northeast-Corridor.pdf

[6] Reference (3) in Exhibit 7-7: TEMS' own studies have identified a number of segments between Washington D.C. and New York that could be improved for a fraction of this cost. For example, the New Jersey "Raceway" from Trenton to Newark is very straight and could accommodate 220-mph service with just a few curve easements. Similarly there is a long stretch of open countryside between Baltimore and Wilmington that could allow development of a 220-mph priority Greenfield segment. We would recommend that these two areas be the first NEC segments to be upgraded to 220-mph. After that however still remain the more difficult built-up areas through downtown Baltimore to Washington, from Wilmington through Philadelphia to Trenton, and from Newark into New York City where adding the needed capacity will be much more expensive. These stretches of Urban Greenfield are why the NEC costs are so much higher than other comparable High Speed rail projects.

[7] However, even in Europe although some projects like this have been completed (for example, the Channel Tunnel Rail Link to King's Cross station on the north side of London) this type of project is clearly the exception rather than the rule.

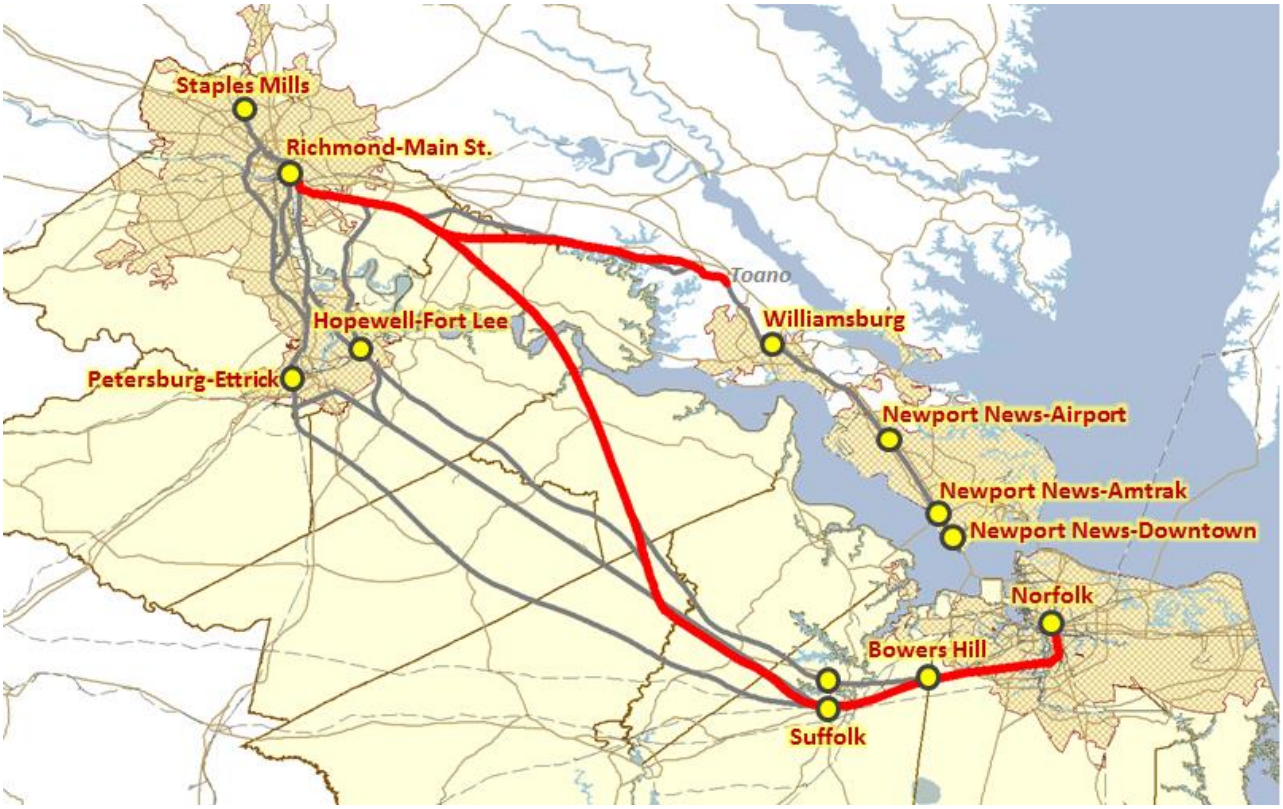
8. PREFERRED OPTION DEVELOPMENT

In this chapter the concept of a preferred option is defined and assessed, and considers how the external benefits to Southeast High-Speed Rail could potentially improve the results for the basic Hampton Roads-Richmond-Washington D.C. service. The assessment is a sensitivity analysis of how these external factors might improve the Financial and Economic results.

8.1 OPTION 4, RICHMOND DIRECT IMPROVED

All of the outcomes of the Phase 2(B) Financial and Economic Analysis for the original Norfolk to Richmond Options 1-3 were very close, but the inclusion of a Peninsula connection in Option 4 dramatically improves the financial and economic performance of the system. As shown in Exhibit 8-1, this study has developed Option 4, Richmond Direct Improved (see Exhibit 8-1) to the same level of detail as the original Option 1-3. This would add a high speed connection to the Peninsula -- from Roxbury to the existing CSX line near Toano. The connection would be only 20 miles in length but would offer Peninsula trains some 140 miles of high speed operation from just outside Williamsburg to Washington. The connector would provide a relatively low cost link to the proposed Richmond Direct alignment.

Exhibit 8-1: Option 4, Richmond Direct Improved



Building this link would improve average train speeds on the Peninsula to a level that would significantly increase demand and would require a train service of 8-10 trains per day. This is comparable with what was envisaged by the HRTPO Board Objective of Enhanced Passenger Rail Service for the Peninsula. Because it would use 130-mph high speed train technology, this connection would provide a two hour connection from Newport News to Washington, and a 1 ½ hour schedule from Williamsburg to Washington. This schedule is also very close to the schedule outlined for the Peninsula Enhanced Passenger Rail Service in Step 4 of the passenger rail development program set out by HRTPO and DRPT.[1]

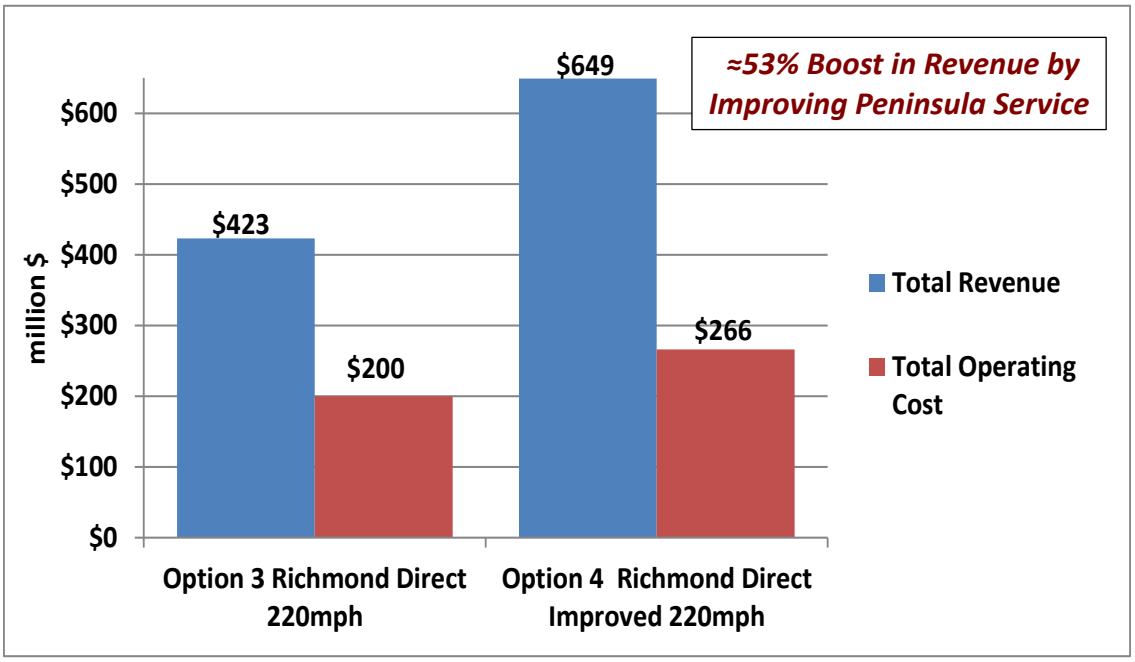
Exhibit 8-2 compares the revenues, operating costs and operating ratios for Richmond Direct Improved, Option 4 with the best of the original options, Richmond Direct, Option 3 for year 2035. Exhibit 8-3 provides a bar chart comparison of revenues and operating costs for Option 4 Richmond Direct Improved and Option 3 Richmond Direct.

Exhibit 8-2: Option 3, Richmond Direct vs Option 4 Richmond Direct Improved
Comparison of Year 2035 Financial Results

Financial 2035 (mill. 2013$)	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improved 220mph
Revenue		
Ticket Revenue	$391	$600
OBS Revenue 8%	$31	$48
Total Revenue	**$423**	**$649**
Total Operating Cost	**$200**	**$266**
Operating Surplus	**$222**	**$383**
Operating Ratio	**2.11**	**2.44**

[1] Step 4 assumed 79-mph operation in the urban areas of Newport News and Williamsburg, 110-mph operation from Williamsburg to Richmond, and 130-mph operation from Richmond to Washington. On the Richmond-Washington segment, the train would use the same tracks as the true high speed option from Norfolk. As a result, the high speed diesel train could operate at a top speed of 130-mph. Option 4 provides for 90-mph operation on the existing CSX alignment and 130-mph running on a new dedicated greenfield passenger alignment from Toano north. As such, Option 4 has a slightly better train time than that proposed in the original development program Step 4.

Exhibit 8-3: Bar Chart Comparing Total Revenue and Operating Cost for Option 3 Richmond Direct vs Option 4, Richmond Direct Improved (Year 2035)



It can be seen that the Operating Ratio is significantly improved for Option 4, rising from 2.11 to 2.44. This considerably improves the case for a public private partnership and/or franchising the system, as it shows a higher level of operating profitability so the system could contribute a higher share of its own capital cost. Exhibit 8-2 and 8-3 show that the proposed Option 4 significantly improves revenues over costs, due to better service of 8-10 trains per day in the Peninsula corridor. These extra trains are required to service the extra demand that the connection to the Richmond Direct route generates. In addition, there are operating cost synergies associated with running Peninsula trains on the Richmond Direct route. These include signal and track maintenance, station staffing, marketing administrative and management costs.

Exhibit 8-4 shows a comparison of the economic results for Option 4 Richmond Direct Improved vs Option 3 Richmond Direct. Exhibit 8-5 and 8-6 compare total benefits vs total costs for Option 4 and Option 3 at the 3% and 7% discount rates. It can be seen that the economic Net Present Value and the Cost Benefit Ratio is enhanced for Option 4. At 3% discount rate, Option 4 has close to a return of twice the capital and operating cost, and even at 7% discount rate it has a significantly higher than 1.0 Cost Benefit Ratio. This is essentially the same high rate of economic return that was developed by the earlier 2010 Preliminary Vision Plan assessment that included both Peninsula and Norfolk service[2].

[2] July 2, 2010, HRTPO Board Presentation, Slide 27

Exhibit 8-4: Comparison of Economic Results at 3% & 7% Discount Rates for Option 3 Richmond Direct vs Option 4 Richmond Direct Improved

	3% Discount Rate		7% Discount Rate	
Discount (million 2013$)	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improvement 220mph	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improvement 220mph
System Passenger Revenues	$4,718	$7,142	$1,578	$2,399
OBS	$377	$571	$126	$192
Users Consumer Surplus	$2,920	$5,870	$987	$1,990
Highway Congestion Savings	$2,454	$2,934	$794	$952
Airport Delay Saving	$424	$479	$137	$155
Safety Benefits	$801	$1,101	$270	$372
Highway Reduced Emissions	$178	$244	$59	$81
Total Benefits	**$11,872**	**$18,340**	**$3,952**	**$6,140**
Capital Cost	$5,010	$5,737	$2,826	$3,236
O&M Costs	$2,357	$3,116	$795	$1,054
Cyclic Mtn	$63	$78	$17	$22
Total Costs	**$7,429**	**$8,931**	**$3,638**	**$4,311**
NPV(Surplus)	**$4,443**	**$9,409**	**$314**	**$1,829**
Benefit/Cost Ratio	**1.60**	**2.05**	**1.09**	**1.42**

Exhibit 8-5: Comparison of Total Benefits and Costs for Option 3 Richmond Direct vs Option 4 Richmond Direct Improved at 3% Discount Rate

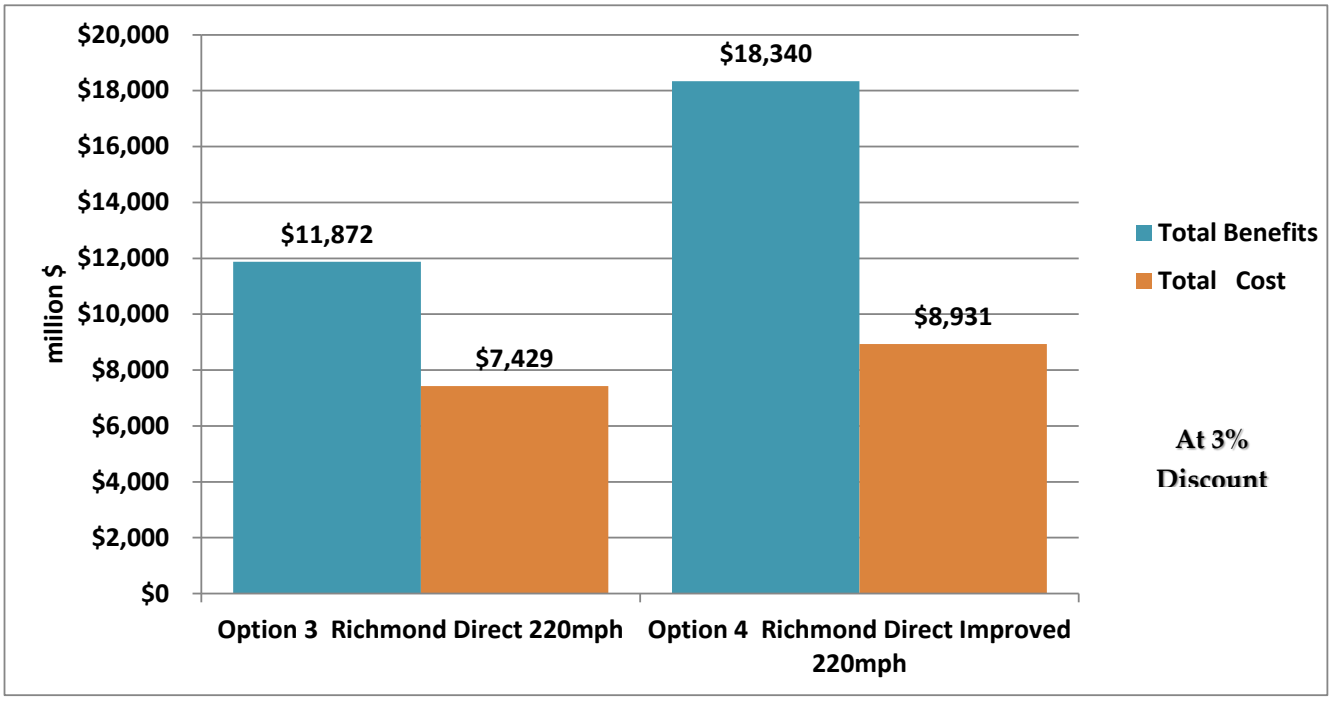


Exhibit 8-6: Comparison of Total Revenues and Costs for Option 3 Richmond Direct vs Option 4 Richmond Direct Improved at 7 % Discount Rate

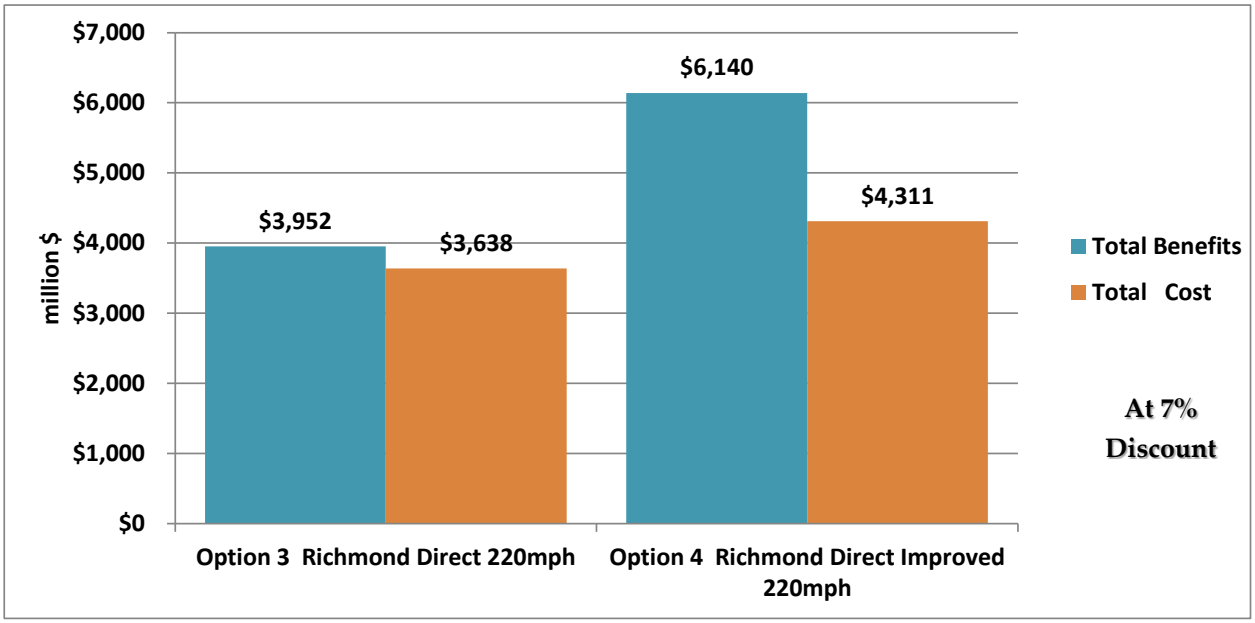


Exhibit 8-7 shows the Economic Cash Flow Analysis for the proposed Option 4, Richmond Direct Improved for the period 2020 (the first year of construction) to 2055 (the assumed life of the project). In the exhibit, economic cash flows were discounted at 3 percent, which is in line with OMB requirements. It can be seen that the project makes a significant operating surplus in its first year of operation that steadily increases over the life of the project, i.e. 2055. This positive cash flow provides a basis for a public/private partnership with a likely contribution of $3-5 billion to total project costs of $6-7 billion, or about a 50% share of total project costs.

Although the Norfolk-Richmond-Washington D.C. corridor investment satisfies the FRA/OMB requirement for achieving a positive cost benefit ratio at 7%, it is clear that adding a Peninsula rail service greatly improves the cost benefit result. While the Norfolk service stands on its own, adding the Peninsula service dramatically improves both the financial and Cost Benefit results of the system. As a result it is recommended that the Peninsula rail service also be included in any future High Speed rail evaluations for this corridor.

Finally, the proposed Hampton Roads-Richmond-Washington D.C. High Speed rail investment would provide a complementary service to the regional incremental and commuter rail systems that are being developed by DRPT between Richmond and Washington. As was found in British Rail experience and elsewhere[3], where commuter and regional rail systems develop parallel to High Speed systems, as is occurring on the north end of the corridor from Fredericksburg into Washington D.C., this actually tends to boost the ridership of both systems. As such the Hampton Roads-Richmond-Washington High Speed Rail corridor can be developed independently of the current planned upgrades to existing rail since each project has independent utility, and the two projects although complementary do not depend on one another for their operational or economic viability.

[3] *Connecting California, 2014 Business Plan*, California High Speed Rail Authority, page 9. "The 2012 Business Plan created the foundation for a statewide rail modernization program with high-speed rail at its core, *and with parallel investments in urban, commuter and intercity rail systems* that together will significantly improve mobility and connectivity throughout the state." (emphasis added.) See: http://www.hsr.ca.gov/docs/about/business_plans/BPlan_2014_Business_Plan_Final.pdf

Exhibit 8-7: Option 4, Richmond Direct Improved
Detailed Economic Benefits and Costs Flows by Year ($2013 Millions)

Benefit and Costs Items		Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Benefits to Users	**NPV at 3%**													
	System Passenger Revenues	$7,141.82	-	-	-	-	-	-	-	-	-	-	559.37	567.36
	OBS	$571.35	-	-	-	-	-	-	-	-	-	-	44.75	45.39
	Total Operating Revenues	**$7,713.17**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**604.12**	**612.75**
	Users Consumer Surplus	$5,869.63	-	-	-	-	-	-	-	-	-	-	482.68	487.86
	Total User Benefits	**$13,582.79**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1,086.80**	**1,100.61**
Benefits to Public at Large														
	HWY Congestion Savings	$2,933.91	-	-	-	-	-	-	-	-	-	-	183.50	190.53
	Airport Delay Saving	$478.62	-	-	-	-	-	-	-	-	-	-	30.56	31.47
	Safety Benefits	$1,100.72	-	-	-	-	-	-	-	-	-	-	89.20	90.26
	Highway Reduced Emissions	$243.88	-	-	-	-	-	-	-	-	-	-	17.91	18.29
	Total Public at Large Benefits	**$4,757.12**	-	-	-	-	-	-	-	-	-	-	321.16	330.53
Total Benefits		**$18,339.91**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1,407.96**	**1,431.15**
Costs														
	Capital Cost	$5,737.14	8.10	8.10	8.10	16.20	299.78	847.48	1,487.55	2,407.95	2,336.65	1,544.27	-	-
	O&M Costs	$3,115.98	-	-	-	-	-	-	-	-	-	-	257.34	258.94
	Cyclic Mtn	$77.96	-	-	-	-	-	-	-	-	-	-	-	-
Total Costs		**$8,931.09**	**8.10**	**8.10**	**8.10**	**16.20**	**299.78**	**847.48**	**1,487.55**	**2,407.95**	**2,336.65**	**1,544.27**	**257.34**	**258.94**
Benefit - Costs		**$9,408.83**	**($8.10)**	**($8.10)**	**($8.10)**	**($16.20)**	**($299.78)**	**($847.48)**	**($1,487.55)**	**($2,407.95)**	**($2,336.65)**	**($1,544.27)**	**$1,150.62**	**$1,172.20**

Exhibit 8-7: Option 4, Richmond Direct Improved
Detailed Economic Benefits and Costs Flows by Year ($2012 Millions) (con't)

Benefit and Costs Items		Year	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Benefits to Users	**NPV at 3%**													
	System Passenger Revenues	$7,141.82	575.46	583.68	592.02	600.48	609.59	618.84	628.23	637.76	647.44	657.26	667.24	677.36
	OBS	$571.35	46.04	46.69	47.36	48.04	48.77	49.51	50.26	51.02	51.80	52.58	53.38	54.19
	Total Operating Revenues	**$7,713.17**	**621.50**	**630.38**	**639.39**	**648.52**	**658.36**	**668.35**	**678.49**	**688.78**	**699.23**	**709.84**	**720.61**	**731.55**
	Users Consumer Surplus	$5,869.63	493.10	498.39	503.74	509.15	514.48	519.87	525.32	530.82	536.38	542.00	547.68	553.41
	Total User Benefits	**$13,582.79**	**1,114.60**	**1,128.77**	**1,143.13**	**1,157.67**	**1,172.84**	**1,188.22**	**1,203.81**	**1,219.60**	**1,235.61**	**1,251.84**	**1,268.29**	**1,284.96**
Benefits to Public at Large														
	HWY Congestion Savings	$2,933.91	197.82	205.40	213.27	221.44	228.37	235.52	242.89	250.49	258.33	266.42	274.76	283.36
	Airport Delay Saving	$478.62	32.40	33.36	34.36	35.38	36.56	37.78	39.04	40.34	41.68	43.07	44.51	45.99
	Safety Benefits	$1,100.72	91.33	92.41	93.51	94.62	95.74	96.88	98.03	99.19	100.37	101.56	102.76	103.98
	Highway Reduced Emissions	$243.88	18.67	19.07	19.47	19.88	20.28	20.68	21.10	21.52	21.95	22.39	22.83	23.29
	Total Public at Large Benefits	**$4,757.12**	340.23	350.25	360.61	371.32	380.95	390.86	401.05	411.54	422.33	433.44	444.86	456.62
Total Benefits		**$18,339.91**	**1,454.83**	**1,479.02**	**1,503.74**	**1,528.99**	**1,553.79**	**1,579.08**	**1,604.86**	**1,631.15**	**1,657.95**	**1,685.28**	**1,713.16**	**1,741.59**
Costs														
	Capital Cost	$5,737.14	-	-	-	-	-	-	-	-	-	-	-	-
	O&M Costs	$3,115.98	260.56	262.18	263.81	265.45	268.79	272.17	275.60	279.06	282.57	286.13	289.72	293.37
	Cyclic Mtn	$77.96	-	-	3.14	3.14	3.14	5.49	5.49	5.49	7.84	7.84	7.84	7.84
Total Costs		**$8,931.09**	**260.56**	**262.18**	**266.95**	**268.59**	**271.93**	**277.66**	**281.09**	**284.55**	**290.41**	**293.97**	**297.57**	**301.21**
Benefit - Costs		**$9,408.83**	**$1,194.27**	**$1,216.84**	**$1,236.79**	**$1,260.40**	**$1,281.86**	**$1,301.42**	**$1,323.77**	**$1,346.59**	**$1,367.53**	**$1,391.31**	**$1,415.59**	**$1,440.38**

Exhibit 8-7: Option 4, Richmond Direct Improved
Detailed Economic Benefits and Costs Flows by Year ($2012 Millions) (con't)

Benefit and Costs Items		Year	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055
Benefits to Users	**NPV at 3%**													
	System Passenger Revenues	$7,141.82	687.64	698.07	708.66	719.42	730.33	741.41	752.66	764.08	775.68	787.44	799.39	811.52
	OBS	$571.35	55.01	55.85	56.69	57.55	58.43	59.31	60.21	61.13	62.05	63.00	63.95	64.92
	Total Operating Revenues	**$7,713.17**	**742.65**	**753.92**	**765.36**	**776.97**	**788.76**	**800.73**	**812.87**	**825.21**	**837.73**	**850.44**	**863.34**	**876.44**
	Users Consumer Surplus	$5,869.63	559.21	565.07	570.99	576.97	583.01	589.12	595.29	601.53	607.83	614.19	620.63	627.13
	Total User Benefits	**$13,582.79**	**1,301.86**	**1,318.98**	**1,336.34**	**1,353.94**	**1,371.77**	**1,389.84**	**1,408.16**	**1,426.73**	**1,445.56**	**1,464.63**	**1,483.97**	**1,503.57**
Benefits to Public at Large														
	HWY Congestion Savings	$2,933.91	292.23	301.37	310.81	320.54	330.57	340.92	351.59	362.59	373.94	385.64	397.72	410.16
	Airport Delay Saving	$478.62	47.53	49.11	50.75	52.44	54.19	56.00	57.86	59.79	61.79	63.85	65.98	68.18
	Safety Benefits	$1,100.72	105.21	106.46	107.72	109.00	110.29	111.60	112.93	114.27	115.62	116.99	118.38	119.78
	Highway Reduced Emissions	$243.88	23.76	24.23	24.71	25.21	25.71	26.22	26.75	27.28	27.83	28.38	28.95	29.53
	Total Public at Large Benefits	**$4,757.12**	468.72	481.18	494.00	507.19	520.76	534.74	549.13	563.93	579.18	594.87	611.02	627.65
Total Benefits		**$18,339.91**	**1,770.58**	**1,800.16**	**1,830.34**	**1,861.12**	**1,892.53**	**1,924.58**	**1,957.29**	**1,990.67**	**2,024.73**	**2,059.50**	**2,094.99**	**2,131.22**
Costs														
	Capital Cost	$5,737.14	-	-	-	-	-							
	O&M Costs	$3,115.98	297.06	300.79	304.58	308.41	312.28	316.21	320.19	324.22	328.29	332.42	336.60	340.84
	Cyclic Mtn	$77.96	7.84	11.76	11.76	11.76	11.76	11.76	15.68	15.68	15.68	15.68	15.68	15.68
Total Costs		**$8,931.09**	**304.90**	**312.56**	**316.34**	**320.17**	**324.05**	**327.98**	**335.87**	**339.90**	**343.98**	**348.11**	**352.29**	**356.52**
Benefit - Costs		**$9,408.83**	**$1,465.68**	**$1,487.61**	**$1,514.00**	**$1,540.95**	**$1,568.49**	**$1,596.61**	**$1,621.42**	**$1,650.77**	**$1,680.75**	**$1,711.39**	**$1,742.71**	**1,774.70**

8.2 IMPLICATIONS FOR FRANCHISABILITY

For quite some time, the private sector has been providing contract operations of transit systems. For example, VRE's commuter rail service has been operated by Keolis[4] since 2010. In 2012, Maryland awarded the operating contract for its MARC Camden and Brunswick lines to Bombardier.[5] Under PRIIA §209, states are even entitled to contract out state-supported intercity rail corridor operations in part or in whole.[6] Indiana has recently competitively bid the Chicago to Indianapolis "Hoosier State" train.[7]

However, unlike the transit services above, one of the implications of having a positive cash flow is that it expands the potential scope for private sector participation in the project. This means that the private sector can directly contribute to the capital cost of the project, and can also assume a more active role in making key business decisions and directly managing the service under a variety of possible franchise arrangements. These range from total ownership and control of the project, to more limited arrangements that involve a greater degree of public participation. The public sector has also applied similar models to highway system development, particularly toll roads.

An example of a highly successful Public-Private Partnership (PPP) project in Virginia are the I-495 toll lanes recently completed by Transurban[8] and Fluor,[9] where private sector funds covered more than ¾ of the cost of the project. Maryland has recently requested private sector input on best practices and innovative approaches to deliver and finance the Maryland National Capital Purple Line and Baltimore Red Line projects.[10] A PPP approach is also appropriate for High Speed rail as was advocated by the US Federal Railroad Administration in their groundbreaking 1997 *Commercial Feasibility Study*.[11] This fundamental USDOT policy document laid the groundwork for numerous rail PPP initiatives:

- British Rail/Bechtel Michigan in 1985[12]
- Florida FOX in 1996[13]
- Texas TGV in 1990[14]
- Tampa-Orlando HSR in 2011[15]
- Victorville to Las Vegas in 2012[16]
- Orlando-Miami: All Aboard Florida, ongoing[17]
- Dallas-Houston: Texas Central Railway, ongoing[18]

[4] See http://news.fredericksburg.com/transportation/2014/04/18/vre-re-ups-contract-with-operator-keolis/
[5] See http://www.railwayage.com/index.php/passenger/commuter-regional/bombardier-to-operate-marc-camden-brunswick-lines.html?channel=
[6] See: http://www.railwayage.com/index.php/blogs/frank-n-wilner/competitive-bidding-for-corridor-passenger-rail-service-in-play.html and Item #6 of http://www.highspeed-rail.org/Documents/PRIIA%20305%20DocSpec%20and%20other%20NGEC%20Documents/PRIIA%20Section%20209%20%20FAQs%20061011.pdf
[7] See http://www.ibj.com/four-private-companies-bid-on-hoosier-state-route/PARAMS/article/47507 , http://indianaeconomicdigest.com/main.asp?SectionID=31&SubSectionID=66&ArticleID=74153 , http://www.indystar.com/story/news/politics/2014/04/02/wanted-operator-keep-hoosier-state-track/7235971/
[8] http://www.transurban.com/
[9] See: http://tollroadsnews.com/news/how-fluor-lane-widened-the-495-capital-beltway-from-8-to-12-lanes-interview
[10] Maryland transit officials request private-sector input on Purple, Red line light-rail projects, see http://www.progressiverailroading.com/passenger_rail/news/Maryland-transit-officials-request-privatesector-input-on-Purple-Red-line-lightrail-projects--35857
[11] See: https://www.fra.dot.gov/Elib/Document/1177
[12] See: http://news.google.com/newspapers?nid=1988&dat=19850727&id=xGMiAAAAIBAJ&sjid=yasFAAAAIBAJ&pg=1434,2228266
[13] See: http://www.alstom.com/press-centre/1999/1/Statement-on-Florida-TGV-19990114/
[14] See: http://www.psmag.com/navigation/business-economics/how-high-speed-rail-died-in-texas-thrived-in-spain-32021/
[15] See: http://www.politifact.com/florida/statements/2011/aug/11/rick-scott/gov-scott-says-rail-would-have-cost-state-taxpayer/
[16] http://www.xpresswest.com/
[17] See: http://www.allaboardflorida.com/

A common thread in past "failures" has never been the private sector's willingness to participate. Rather without exception, it has been a failure of political will on the part of the public sector partner that prevented projects from moving forward.[19] Instead, the fundamental strength of the Florida and Texas markets, coupled with an opportunity to economically develop new infrastructure, has repeatedly stimulated private sector interest in these corridors:

- *All Aboard Florida's* effort represents the third attempt by the private sector to improve passenger rail in that state and by all accounts, it looks like it will succeed this time and likely even extend to Tampa and/or Jacksonville in the next development phase.[20]
- *Texas Central Railway's* effort is the second serious attempt by the private sector in Texas. The private sector is able to completely finance the cost for building rural greenfields from Dallas to Houston. They will need help covering the capital cost for extending the line into Fort Worth because of higher urban greenfield construction costs.[21] Once the line is built however, it can be expected to operate profitably.
- *XpressWest's* Los Angeles to Las Vegas connection has long been identified as a key opportunity for introduction of High Speed rail, and so the corridor has been subject of numerous competing private sector proposals. Although the RRIF loan application was denied for Victorville to Las Vegas based on a park-and-ride concept, the private consortium remains in place and still engaged in active development of the corridor. Currently they are attempting to resolve connectivity issues with California HSR so the system can provide a single seat ride to downtown Los Angeles. It seems reasonable to assume that this project will resume on a firmer economic foundation once this issue is resolved.

It can be seen that PPP initiative can be a viable approach to development of a High Speed rail system and that similar PPP funding mechanisms have been successfully applied in Virginia. Given an overall capital cost of around $9 Billion (in 2013 dollars) and an assumed 40% private sector contribution of $3.6 Billion, an USDOT FRA contribution of 30-40 percent based on previous PPP projects (USDOT offered 35% to the Florida FOX project). Virginia would need to find a way to fund 20-25 percent of the remaining capital share, or $1.8 to $2.2 Billion over 10 years.

As noted, much of this remaining capital funding would likely be provided by Federal dollars but this expenditure is clearly justifiable since it has been shown to provide a strong positive Cost Benefit ratio at the OMB's rationing hurdle rate of 7%. In fact there are very few infrastructure projects in Virginia or nationally that can demonstrate such a strong positive economic result.

[18] See: http://www.texascentral.com/
[19] *"Fares, Finance and Funding*" Presentation to High Speed Rail Association, March 2012, Dr. Alexander E. Metcalf
[20] See http://tbo.com/news/business/tampa-wants-all-aboard-florida-rails-to-run-its-way-20131003/
[21] *Texas Central Railway said it will use a market-driven approach, which includes picking routes and stations based on consumer demand, not politics. It also wants no grants or subsidies. . . The catch is that the private, for-profit company won't build the 30-mile spur. Unlike the longer line from Dallas to Houston, the numbers don't work on a shorter line, because construction costs are much higher in urban areas*. See: http://www.dallasnews.com/business/columnists/mitchell-schnurman/20140407-public-tie-could-slow-bullet-train-plan.ece

8.3 POSSIBLE SYNERGIES WITH SOUTHEAST HIGH SPEED RAIL

One of the major problems with the currently proposed triple track expansion of passenger rail service north from Richmond to Washington D.C. is a lack of sufficient capacity to accommodate Hampton Roads' needs. As a result there is clearly no room north of Richmond for the proposed High Speed services from Norfolk and Newport News to Washington D.C. as proposed in Option 4, so the development of an alternative greenfield route and a capacity improvement plan that goes beyond DRPT's current plan is needed.

One option therefore might be to consider moving the planned SEHSR services to the new HRTPO High Speed route north of Richmond. If SEHSR chooses to do this, they could run their diesel trains up to 130-mph "under the wire" just as has been proposed for the Peninsula diesel service. On this basis the SEHSR trains could reduce their running time from 2:00 down to 1:05 by using the proposed new greenfield alignment to Washington D.C.

Doing this would afford SEHSR a significant travel time savings so the proposed greenfield would undoubtedly offer an attractive route alternative for them. This would also develop additional economic benefits that are not currently included in the Cost Benefit analysis. Clearly SEHSR's planned four round trips[22] are not enough to support greenfield route development on their own; but since Hampton Roads would provide the base volume needed to support development of this greenfield corridor, SEHSR could take advantage of it as an incremental user. This would also relieve CSX of the responsibility for hosting these passenger trains on its tracks north of Richmond.

These cost sharing opportunities and the additional benefits to SEHSR might be worth as much as a 15% capital sharing opportunity which would boost the Cost Benefit ratio (at 7%) from 1.42 up to the neighborhood of 1.6. This potential for SEHSR integration clearly makes the business case for developing Option 4 even stronger and may even further expand the potential scope for private sector participation in funding this project.

8.4 CONCLUSION

In addition to improving ridership and relieving traffic congestion within the Norfolk to Richmond corridor, the Option 4, Richmond Direct Improved 220-mph technology option would benefit ridership and revenues for the system and relieve traffic congestion outside the Norfolk to Richmond corridor (i.e. benefits to the Peninsula and Richmond to DC segments). Option 4 also provides a superior Financial and Economic return (Operating Ratio, Benefit-Cost Ratio) when compared with results for addressing only the Norfolk to Richmond corridor. This could be further improved by considering integration with SEHSR in the next phase of work.

[22] See FAQ #11 of http://www.sehsr.org/faq.html

9. CONCLUSIONS

This chapter describes the key results of the study.

9.1 RESULTS

The analysis shows that the potential for developing a true high speed system for the Hampton Roads Corridor is very real. It is clear that greenfield routes can be developed that, from the initial market operations, engineering and environmental analysis, would attain USDOT FRA financial and economic requirements, have independent utility both in their entirely and on a segmented basis, and also could avoid obvious[1] environmental "fatal flaws" that would prevent their construction.

In terms of the specific results, it was found that all of the initial Norfolk-Richmond Corridor Options 1-3 were very close. All the options produced positive financial operating ratios although 220-mph options showed better economic returns than 130-mph options. The results for Richmond Direct (Option 3) were marginally better than the two Southern routes (Options 1A and 1B) via Petersburg or the two Northern routes (Options 2A and 2B) via Hopewell (Exhibit 7-2) because Option 3 avoids the need for high-cost construction within the built-up urban areas that lie south of Richmond.

However, it was also noticed that Option 3 in particular creates an opportunity for significant track sharing with the Peninsula east of Richmond, whereas Option 1 offers no such opportunity, and Option 2 would allow sharing only to a limited extent. Since Option 3 was also the best-performing Richmond to Norfolk option, it was enhanced in Option 4 by adding a Peninsula rail connection. This was shown to significantly boost the financial and economic performance of the system, so now Option 4 stands clearly above any of the other Options 1-3.

The projected financial and economic performance of the corridor now ranks it among one of the best opportunities for development of High Speed Rail in the United States outside the Northeast Corridor. In the case of all the options, but in particular with the Richmond Direct Improved Option 4, the results show a great potential for attracting a Public Private Partnership (P3). A P3 will be attracted by the strong financial result that suggests an operating surplus exceeding $300 million per year could be generated by 2035 (See Exhibit 8-6). The P3 potential is also enhanced by the efficient infrastructure development approach where greenfields are maximized in rural areas where they can be economically constructed, while existing rail lines are enhanced to add the capacity needed to directly reach the urban core markets of Norfolk, Newport News, Richmond and Washington D.C. As has been shown in Europe and elsewhere this is the most cost effective approach to the development of High Speed rail systems since it makes the cost affordable as compared to highways, airports, upgrading existing rail tracks or other options for expanding intercity transportation capacity.

[1] This is based on an environmental scan level of review. Environmental data has been collected and assessed at a landscape level consistent with FRA's requirements for a Service NEPA. A landscape level of review refers to preliminary overview of the area and prospective alignments based on mapping, and aerial and ground level photographs, without detailed on-site inspection.

To move towards implementing the HRTPO Objectives, it is recommended to:

- Clarify with DRPT that there is no room for HRTPO high and higher speed train on the CSX route from Richmond to Washington. A greenfield route is the only solution if high and higher speed rail is to be a possible mechanism for improving mobility in Eastern Virginia.
- Continue development of the Richmond-Washington D.C. segment to define greenfield alternatives and develop a preliminary assessment at the feasibility level is critical. This would lead to the creation of a Service NEPA document and in the short term, some possible additional alternatives, such as greenfield bypasses around Ashland and Fredericksburg, might even be incorporated as useful adjuncts to DRPT's current Tier II EIS planning for incremental rail. For longer term development needs, establishing route reservations in Master Planning documents to protect the needed rights-of-way to prevent the kinds of cost escalation that were experienced by California's system.
- Continue development of the Richmond Direct Improved Option for the benefit of both the North and Southside Hampton Roads communities. Feasibility work still remains to be completed for defining, refining and optimizing additional greenfield Peninsula route options as well as working with CSX on capacity analysis east of Toano, and for possible development of a downtown Newport News station and how that might impact CSX's Newport News terminal operations. (However, the Option 4 proposed budget of $100 million for the passenger service extension east of Bland Blvd provides ample room for needed capacity mitigation here.) The Richmond Direct Improved Option is a very cost effective way of developing higher speed options for the Peninsula, as well as achieving the high speed objectives of the Southside. It will give both communities the higher and high speed options the HRTPO Board is seeking.
- Continue discussions with Portsmouth and Suffolk to advance development of the "V-Line" and Bowers Hill stations in the short to medium term.
- Engage SEHSR in a discussion of the synergies and benefits potentially associated with sharing a new High Speed alignment, particularly north of Richmond up to Washington D.C. SEHSR trains are capable of 110 to 130 mph but will be significantly (50-60 mph) constrained on the Richmond to Washington CSX route.
- Develop the institutional framework to support a process for Public Private Partnership Development throughout the Environmental Process. This involves holding regular workshops with potential P3 partners through the environmental process. Identify the potential financial parameters for a public-private partnership considering: Design, Build, Operate, Maintain and Finance (DBOM-F) options similar to the approach in Florida that attracted $1.8 Billion in USDOT FRA money for a P3 project between Miami-Orlando-Tampa. USDOT FRA is emphasizing the need for Public Private Partnerships as the mechanism to build High Speed Rail.
- Develop partnership with freight railroads for engaging in right-of-way discussions, and further develop line capacity simulations of shared segments east of Toano, north of Aquia and on a short stretch through downtown Richmond to confirm the adequacy of planned infrastructure for accommodating both High Speed rail and future freight capacity needs.

PUBLIC COMMENTS

Norfolk Southern Corporation
3 Commercial Place
Norfolk, VA 23510-9207

Chris Wichman
Transportation Planner
Hampton Roads Transportation Planning Organization
723 Woodlake Drive
Chesapeake, VA 23320

Mr. Wichman,

Norfolk Southern (NS) appreciates the opportunity to continue to comment on the Hampton Roads Passenger Rail Vision Plan. NS submitted comments to HRTPO in February, and those comments were incorporated into a revised version of the study. We believe that there is still some ambiguity related to the use of NS right-of-way between Norfolk, VA and Petersburg, VA, even in this revised version. Hopefully the material we describe below will resolve those ambiguities.

We would appreciate two sets of clarifications in the final version of the study. The language appearing first below should appear at the front of the report to provide clarity and context regarding the use of NS right-of-way. Additionally, where there is a reference, textual, visual, or otherwise to our right-of-way, we ask that a footnote be placed on that page that reminds the reader of the restrictions NS places on high-speed passenger trains utilizing its corridors. That footnote language appears below as well.

Section 1.1.1

Throughout this study, there will be textual and visual references, explicit or otherwise, to the Norfolk Southern (NS) right-of-way that runs from Norfolk, VA to Petersburg, VA where it then connects to CSX to head to Richmond, VA and points north. NS has strict policies regarding passenger rail and how fast passenger trains may travel on NS right of way (ROW). Those policies are summarized below:

- Where higher speed passenger trains share tracks with conventional freight trains, those high speed trains may not exceed 79 mph.
- Passenger trains operating in excess of 79 mph will require dedicated tracks, and may not exceed 90 mph.
- Passenger trains exceeding 90 mph require their own private right-of-way with at least a 50 foot separation between high speed tracks and freight tracks.

These policies are important in the context of this report as they govern any and all high speed passenger train options utilizing NS right-of-way.

Norfolk Southern Corporation
3 Commercial Place
Norfolk, VA 23510-9207

Footnote to be placed at any mention, textual, visual or otherwise, of Norfolk-Petersburg, Norfolk Southern, Norfolk – Richmond along 460 and any other mention where use of NS ROW is referred to either explicitly or is inferred.

*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger trains utilizing it or encroaching upon it.

We believe this additional language is necessary to ensure that readers clearly understand the use of NS right-of-way, if permitted, would only be permitted in a manner that consistent with NS policy, which has conditions not completely compatible with high-speed rail service.

Additionally, NS requests that its passenger policy requirements regarding passenger rail speeds be included in any and all future presentations where NS right-of-way is referred to in any manner.

Lastly, NS requests that any and all references to its Michigan line transaction, specifically in Section 3.1.1 on page 3-3, be removed from future versions of these reports. That transaction was unique and NS does not intend to pursue such a transaction with the Norfolk-Petersburg corridor.

NS appreciates having a voice at the table with the HRTPO and we look forward to continuing our relationship in the future.

Best regards,

Scott Plum

FUTURE
OF HAMPTON ROADS, INC.

Visioning the Future for America's First Region

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Since 1983

September 25, 2014

RESOLUTION BY THE BOARD OF DIRECTORS, FUTURE OF HAMPTON ROADS, INC.

Whereas the Hampton Roads Transportation Planning Organization (HRTPO) began the development of a High Speed Rail Vision Plan in 2009 to evaluate the potential of high speed and enhanced passenger rail service alternatives for the region, the search has resulted in a number of technical reports and has been described as near completion; and

Whereas rail service, specifically high speed rail, has been identified by Future of Hampton Roads as the key transportation element necessary to maintain regional economic competitiveness by effectively connecting the region to economic centers in the northeast, southeast and around the country; and

Whereas it is the opinion of Future of Hampton Roads' Board of Directors that a final report "High Speed Rail Vision Plan" from HRTPO is vital to the region's ability to pursue funding and support for key studies, and improvements in infrastructure for rail service;

Therefore, be it resolved by the Board of Directors for Future of Hampton Roads that the organization formally urges the HRTPO to complete and release the High Speed Rail Vision Plan as soon as possible.

Respectfully submitted,

William W. Crow
Chairman, Future of Hampton Roads

Public Comment #3

COMMONWEALTH of VIRGINIA

Jennifer L. Mitchell
Director

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October 28, 2014

Camelia Ravanbakht
Interim HRTPO Executive Director
The Regional Building
723 Woodlake Drive
Chesapeake, VA 23320

HRTPO
OCT 30 2014
RECEIVED

Dear Camelia:

Thank you for the opportunity to work with the Hampton Roads Transportation Planning Organization (HRTPO) and provide comments to HRTPO's High Speed Rail Vision Plan Alternatives Analysis. As the Alternatives Analysis has been underway, the Department of Rail and Public Transportation (DRPT) has enhanced intercity passenger rail service to Hampton Roads, as evidenced by new service to Norfolk, concluded the Richmond to Hampton Roads Tier I EIS in 2012, and the included three Hampton Roads area legislators in the Virginia-North Carolina Rail Compact. Additionally, DRPT has programmed $82 million in funding in the approved FY2015 – FY2020 six-year plan for service expansion to Norfolk and $20 million in rail funds for the proposed multimodal station in Newport News. As always, we urge the HRTPO to work with DRPT, FRA and the host railroads for coordinated intercity passenger rail improvements. We are committed to working with HRTPO to advancing higher speed rail improvements in a constructive manner that is consistent with Federal priorities and reasonably expected estimates for future funding.

In 2002, the Federal Railroad Administration published the Tier I Record of Decision (ROD) for the Southeast High Speed Rail (SEHSR) from Washington D.C. to Charlotte, North Carolina. The Tier I ROD identified the CSX right-of-way (ROW) as the preferred corridor between Richmond, VA and Washington, D.C. for high speed rail in order to minimize impacts, reduce initial capital investment, and generate benefits of higher speeds in an achievable timeframe. Since 2003, DRPT has been working in collaboration with the North Carolina Department of Transportation and the Federal Railroad Administration (FRA) to conduct the Southeast High Speed Rail (SEHSR) Tier II Environmental Impact Statement (EIS) from Richmond, Virginia, to Raleigh, North Carolina.

In 2010, DRPT was awarded funding from the FRA's High Speed Rail Program to advance the SEHSR Washington D.C. to Richmond segment Tier II EIS. DRPT is actively advancing the

SEHSR Washington D.C. to Richmond Tier II EIS, as well as other potential capital improvements in the corridor that would benefit current passenger rail services. It is critical that DRPT strictly adhere to the requirements of National Environmental Policy Act (NEPA) of 1969 and that clear communication is provided to the public throughout the Washington D.C. to Richmond Tier II EIS process.

FRA has demonstrated that it will support and invest in rail projects that are consistent with its nationwide policies, and projects that have clear and consistent support from the residents of the region. The Alternatives Analysis has been presented as a parallel/concurrent study (to SEHSR efforts) that has the effect of confusing the audience and potentially risking FRA's support of existing plans in the region. As such, DRPT requests that the HRTPO discontinue making reference to the HRTPO High Speed Passenger Rail Vision Plan Alternatives Analysis as a parallel/concurrent study to the FRA sponsored SEHSR studies that are being conducted by DRPT and/or in collaboration with North Carolina DOT in written format and/or public forum.

DRPT wishes to provide the following observations regarding assumptions that have been made in the HRTPO's Hampton Roads High Speed Passenger Rail Vision Plan Alternatives Analysis that have recently been conducted.

- The 2025 ridership forecast assumptions include development of SEHSR service and NEC Future service. This level of ridership is based on approximately $165 billion of capital improvements in the NEC, for which there is no committed sources of funding identified. Absent any committed sources of state or Federal revenues, there is no guarantee that SEHSR service will be implemented by 2025, and NEC Future service is currently projected out to 2040. As such, we believe the 2025 ridership forecasts may be overly optimistic.

- The market analysis was based on travel markets outside of the SEHSR corridor and well outside of the Hampton Roads Region travel market. The ridership forecasts assume speeds of 130MPH and 220MPH that are unobtainable between Richmond and Washington, D.C. without a fully separated greenfield alignment. This assumption is inconsistent with the SEHSR Tier I EIS ROD issued in 2002.

- The Alternatives Analysis report claims no environmental fatal flaws for the recommended alternative. However given the significant presence of wetlands and sensitive resources in this corridor, DRPT has serious concern with this assumption. The U.S. Route 460 Location Study: Draft Supplemental EIS prepared by VDOT documents many of the environmental impacts associated with a potential greenfield project in this corridor. This study assumes use of CSX and Norfolk Southern (NS) ROW in the description of alternatives at speeds of 130MPH and 220MPH. The HRTPO staff and their consultant have been notified that speeds of 79MPH on NS and 90MPH on CSX ROW are the maximum allowable speeds. Further, ROW is not available for the barrier separation that has been identified in the Alternatives Analysis report to accommodate speeds in excess of 130MPH on the CSX or NS ROW.

- The HRTPO study assumes the use of push-pull or double ended trains that have diesel power cars; however, Amtrak does not allow push-pull or double ended trains and will require a "wye" track to turn the trains.

- DRPT is concerned that the capital cost estimate of $8B ($2013) for 193 mile greenfield project between Washington D.C. and Norfolk, VA may be low. Compared to the capital costs identified in the 2010 Amtrak's Vision for High Speed Rail in the Northeast Corridor, which provides a 220MPH service on the existing Northeast Corridor ROW between Washington D.C. and New York City and separate ROW between New York City and Boston MA at $117B for 439 miles. At $260M/mile, the actual cost of the 220MPH service between Washington D.C. to Norfolk, VA would cost in the neighborhood of $51B. We understand and appreciate that the costs of purchasing a 100-foot section of right-of-way in the proposed corridor would be lower than urban greenfield costs in the northeast corridor. However based on this benchmarking, the actual costs of positive train control systems and electrification, and the number of river crossings in the corridor that will require new infrastructure, we are concerned that the capital cost estimates identified in the Alternative Analysis may be understated. As such the resulting cost-benefit ratios to be overly optimistic. As stated in section 4.4, additional capital cost estimating will need to be conducted during any future studies.

- Any assessment of project delivery methods, including public-private partnerships, should be based on realistic prospective of funding resources including the availability of state and Federal funding sources. The comparison of potential project delivery options to the public-private partnerships for managed lane projects does not take into account that in the managed lane projects, the developer has assumed toll revenue risk. The study has cited a number of news articles as evidence of a viable business model for this project. While section 8.2 cites "the lack of political will on the part of the public sector partner" as the primary reason that these previous initiatives have failed, we suspect that the actual reasons are much more complicated and market-driven. DRPT would expect that any future analyses of higher speed rail alternatives would provide a more detailed analysis of project delivery options that would take into account Virginia's legislative framework, market conditions, approaches to risk allocation and achievable implementation timeframes.

Thank you for your ongoing collaboration in transportation and high speed rail planning initiatives. We appreciate your strong support and advocacy for passenger rail service in the Commonwealth, and we look forward to working with HRTPO to advance these initiatives in the future. Please feel free to contact me if you have any questions or concerns.

Best regards,

Jennifer Mitchell

Jennifer Mitchell

PREPARED FOR

HAMPTON ROADS TRANSPORTATION PLANNING ORGANIZATION

HAMPTON ROADS HIGH SPEED PASSENGER RAIL VISION PLAN

APPENDICES

November 2014

PREPARED BY

TEMS

TRANSPORTATION ECONOMICS & MANAGEMENT SYSTEMS, INC.

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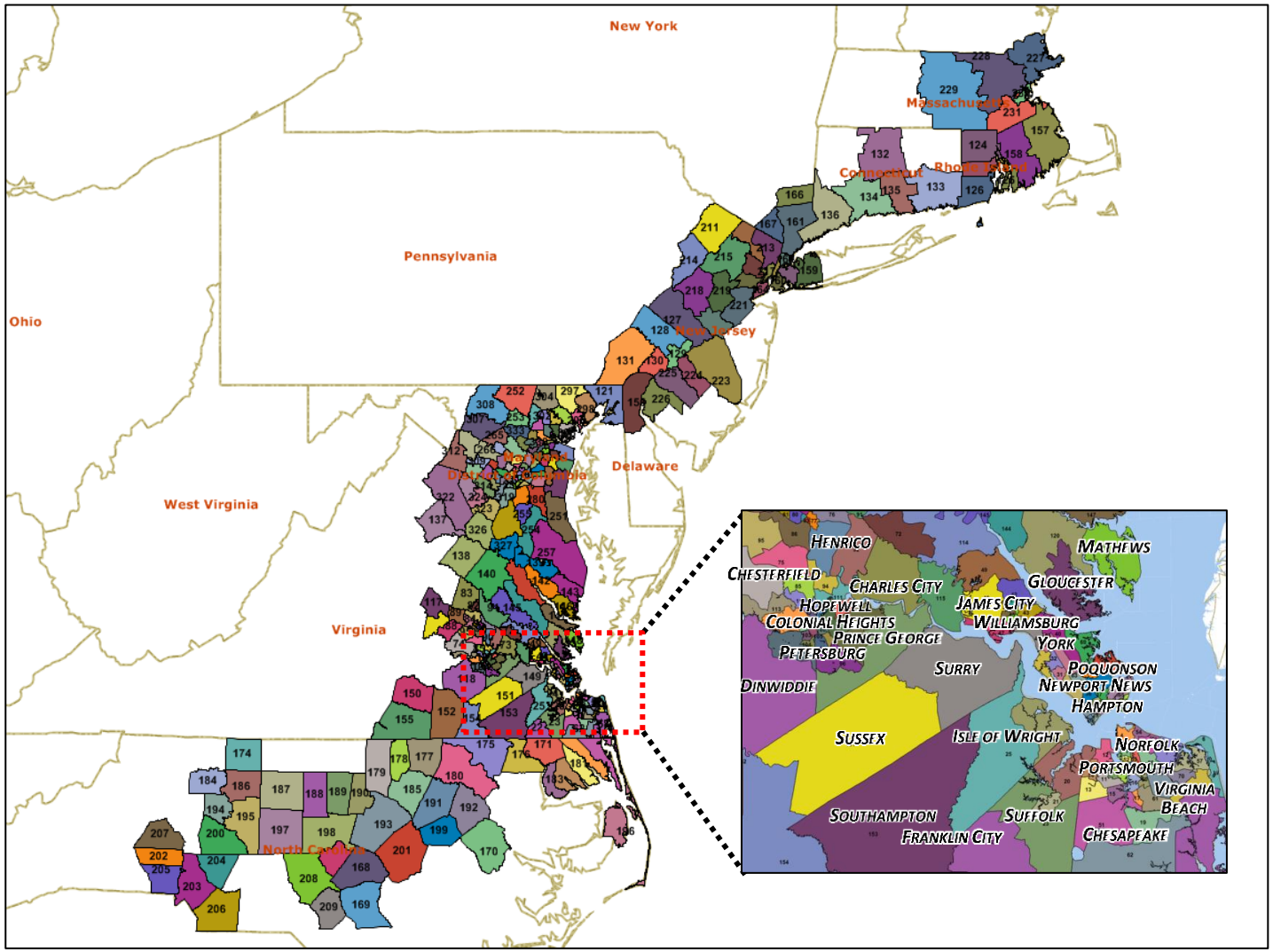
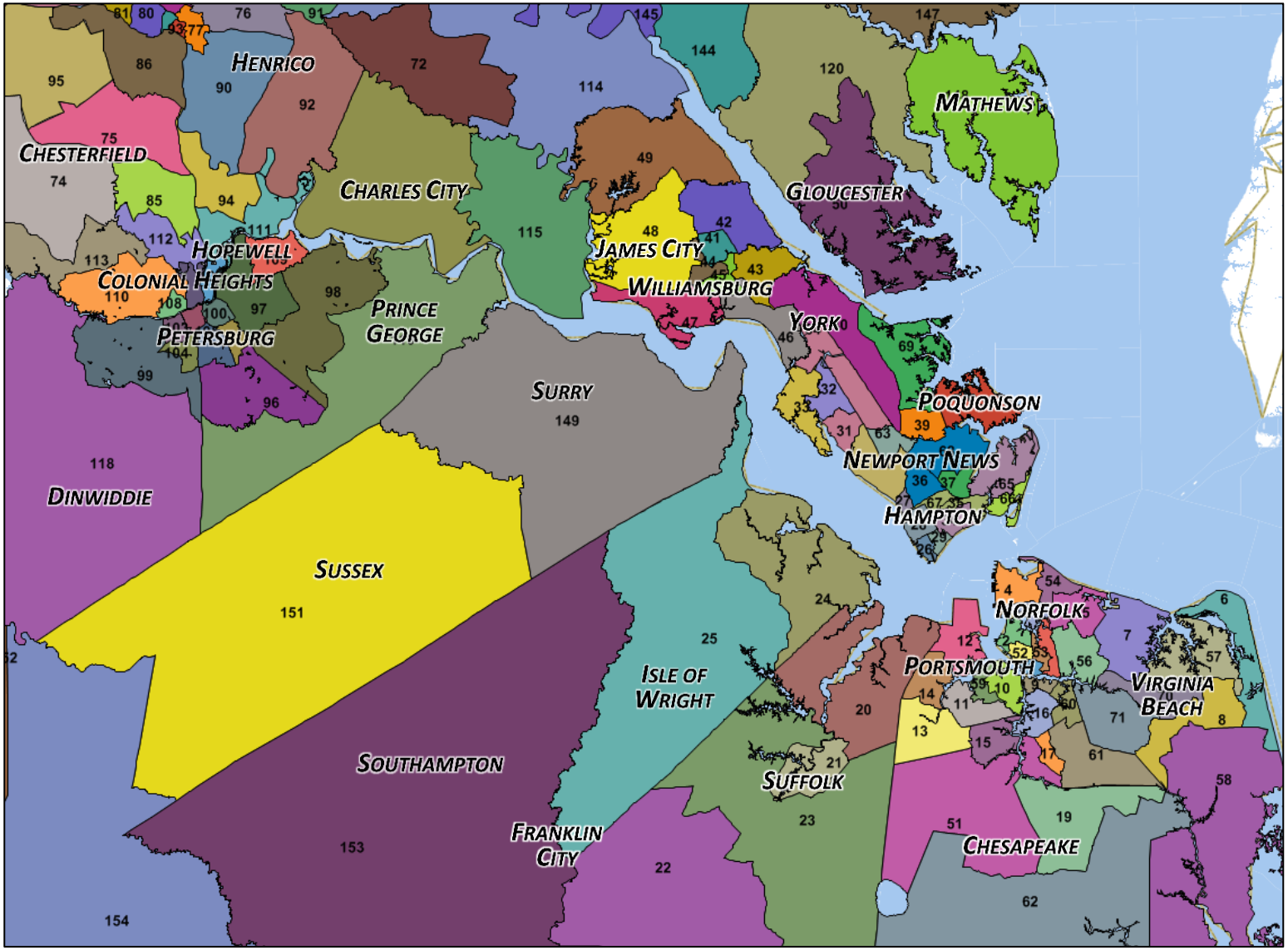
APPENDIX A

1. ZONE SYSTEM AND SOCIOECONOMIC DATA

THE STUDY AREA IS DIVIDED INTO 333 ZONES:



HAMPTON ROADS AREA ZONES:



1.1 Study Area Population Data and Forecasts

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
1	Norfolk (Downtown)	9,217	9,514	10,032	10,578	11,153	11,760	12,249	12,800	13,354
2	Lamberts Point - Colonial Place	21,382	21,436	21,526	21,617	21,708	21,799	21,889	21,980	22,071
3	Fairmount Park - Lafayette Annex	18,326	18,364	18,428	18,493	18,557	18,622	18,685	18,749	18,814
4	Glenwood Park	11,748	11,692	11,598	11,505	11,413	11,321	11,227	11,134	11,041
5	Norfolk International Airport	43,060	43,138	43,270	43,401	43,533	43,665	43,796	43,928	44,059
6	Virginia Beach	42,370	42,786	43,490	44,205	44,932	45,671	46,363	47,080	47,798
7	Chinese Corner	77,205	77,996	79,332	80,691	82,074	83,480	84,794	86,157	87,522
8	Oceana Naval Air Station	33,246	33,803	34,751	35,726	36,728	37,758	38,680	39,659	40,641
9	Berkley - Campostella	7,889	7,901	7,922	7,943	7,964	7,986	8,007	8,028	8,049
10	Portsmouth	23,638	23,774	24,002	24,233	24,466	24,701	24,927	25,158	25,389
11	Victory Park	33,924	34,188	34,633	35,083	35,540	36,002	36,441	36,893	37,345
12	Arostead Forest - Craney Island	25,991	26,080	26,230	26,381	26,532	26,685	26,834	26,984	27,135
13	Bowers Hill	18,319	19,439	21,459	23,689	26,151	28,869	30,673	32,948	35,248
14	Boone	22,559	23,341	24,706	26,150	27,679	29,297	30,582	32,040	33,508
15	Loxley Gardens – Geneva Park	13,605	13,842	14,246	14,662	15,090	15,531	15,924	16,341	16,761
16	South Norfolk	24,795	25,401	26,444	27,529	28,660	29,836	30,837	31,930	33,028
17	1200 Battlefield Blvd N	10,055	10,383	10,953	11,554	12,189	12,858	13,397	14,004	14,614
18	910 Great Bridge Blvd	11,752	12,325	13,343	14,444	15,637	16,928	17,860	18,978	20,106
19	Chesapeake	49,640	51,722	55,387	59,311	63,514	68,015	71,418	75,392	79,395
20	Bennett Corner	34,325	38,694	47,247	57,689	70,440	86,009	92,409	103,429	114,681
21	Suffolk	16,852	17,746	19,344	21,085	22,983	25,052	26,503	28,273	30,060
22	Holland	6,352	6,713	7,359	8,068	8,846	9,698	10,280	11,002	11,731
23	Kings Fork	27,651	30,808	36,889	44,170	52,888	63,328	68,070	75,695	83,466
24	Smithfield	22,030	23,819	27,128	30,898	35,191	40,081	42,901	46,782	50,716
25	Zuni	13,369	14,312	16,033	17,962	20,123	22,543	24,048	26,024	28,023

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
26	Newport News (Downtown South)	8,232	8,222	8,206	8,190	8,173	8,157	8,141	8,124	8,108
27	Newport News Amtrak Station	6,276	6,265	6,245	6,226	6,207	6,187	6,168	6,148	6,129
28	Newport News (Downtown Peninsula)	13,646	13,524	13,324	13,127	12,932	12,741	12,538	12,341	12,145
29	Newport News (Reed)	10,848	10,893	10,969	11,045	11,122	11,199	11,274	11,350	11,426
30	Glendale - Beaconsville	37,195	37,921	39,161	40,442	41,764	43,130	44,331	45,618	46,910
31	Charles	19,225	19,498	19,963	20,439	20,926	21,424	21,878	22,355	22,834
32	Sunsan Constant Dr	28,317	28,568	28,992	29,422	29,859	30,302	30,719	31,150	31,582
33	2 Shore Park Dr	5,720	5,687	5,631	5,576	5,522	5,468	5,412	5,357	5,302
34	Hampton (West)	17,005	16,871	16,650	16,432	16,216	16,003	15,779	15,561	15,344
35	Hampton (Downtown)	9,460	9,461	9,463	9,466	9,468	9,471	9,473	9,476	9,478
36	Fox Corner	21,827	22,261	23,003	23,770	24,563	25,382	26,100	26,871	27,645
37	Chapel Village	16,171	16,441	16,900	17,372	17,858	18,357	18,804	19,278	19,754
38	Poquoson	12,097	12,378	12,860	13,361	13,882	14,423	14,887	15,391	15,898
39	Yorktown (Rt. 134 & Rt. 600)	19,264	19,717	20,496	21,306	22,149	23,024	23,773	24,589	25,407
40	Yorktown (West)	13,370	14,201	15,703	17,363	19,199	21,229	22,567	24,261	25,974
41	Greensprings-Plantation Heights	629	717	893	1,112	1,384	1,723	1,849	2,082	2,320
42	Skimino	3,019	3,357	4,007	4,783	5,710	6,816	7,326	8,138	8,965
43	Charleston Heights - York Terrace	7,052	7,365	7,917	8,512	9,151	9,837	10,348	10,950	11,557
44	Williamsburg	7,786	7,992	8,348	8,720	9,108	9,513	9,853	10,227	10,603
45	Williamsburg (Southeast - Forest Hill Park)	7,381	7,814	8,594	9,451	10,394	11,431	12,130	13,004	13,887
46	James Terrace - Grove	9,857	9,970	10,161	10,355	10,553	10,755	10,943	11,138	11,333
47	Jamestown - Hollybrook	17,065	17,302	17,704	18,115	18,535	18,966	19,358	19,771	20,184
48	Canterbury Hills - Jamestown Farms	28,078	30,688	35,588	41,270	47,859	55,501	59,555	65,439	71,415
49	Toano	13,967	15,840	19,538	24,098	29,723	36,662	39,366	44,199	49,138

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
50	Gloucester	19,404	20,181	21,548	23,006	24,564	26,226	27,500	28,975	30,462
51	Grassfield - Chesapeake Regional Apt.	15,475	16,656	18,829	21,286	24,063	27,203	29,076	31,600	34,156
52	Gent-Park Place	30,087	30,381	30,877	31,382	31,895	32,416	32,905	33,411	33,918
53	Huntersville (Hunter's Village)	15,920	15,963	16,034	16,106	16,178	16,251	16,322	16,394	16,466
54	Ocean View - Willoughby Beach	34,914	34,890	34,850	34,809	34,769	34,729	34,688	34,648	34,608
55	Sussex - Wards Corner	16,360	16,400	16,467	16,534	16,601	16,669	16,735	16,802	16,869
56	Thomas Corner	36,879	36,813	36,703	36,593	36,484	36,375	36,265	36,156	36,046
57	London Bridge	67,655	67,673	67,702	67,731	67,760	67,790	67,819	67,848	67,877
58	Nimmo-Woodhouse Corner	66,081	67,008	68,581	70,191	71,839	73,525	75,063	76,678	78,298
59	Westhaven Park	12,917	12,764	12,512	12,266	12,024	11,787	11,531	11,285	11,040
60	Hawthorne Drive, Chesapeake	20,986	21,186	21,522	21,864	22,211	22,563	22,895	23,237	23,580
61	Shenandoah Pkwy	27,222	28,939	32,046	35,485	39,294	43,512	46,273	49,785	53,336
62	St. Brides	14,009	14,590	15,614	16,709	17,881	19,135	20,087	21,196	22,312
63	Deer Park - Harpersville	14,857	15,421	16,409	17,460	18,579	19,769	20,694	21,757	22,827
64	Newport News/Williamsburg International Airport	36,409	37,375	39,040	40,780	42,598	44,496	46,089	47,841	49,602
65	Hampton (East)	38,334	38,005	37,463	36,929	36,402	35,883	35,334	34,800	34,268
66	504 E Mercury Blvd	16,654	16,911	17,349	17,797	18,258	18,730	19,157	19,607	20,059
67	Greenwood Farms	6,599	6,549	6,467	6,385	6,305	6,225	6,142	6,060	5,979
68	Drummonds Corner	10,786	10,937	11,194	11,457	11,727	12,002	12,253	12,517	12,782
69	Yorktown - Grafton	22,813	23,347	24,265	25,219	26,210	27,240	28,123	29,082	30,046
70	Pecan Gardens	65,992	66,395	67,072	67,757	68,448	69,147	69,818	70,503	71,190
71	Acredale	94,472	95,285	96,656	98,047	99,458	100,889	102,241	103,635	105,031
72	Woodhaven Shores - New Kent Co. Airport	10,517	11,125	12,153	13,194	14,237	15,282	16,331	17,351	18,390
73	Charles City	4,995	5,027	5,088	5,154	5,221	5,287	5,356	5,413	5,478
74	Swift Creek Resevoir	64,047	70,645	81,720	92,879	104,065	115,261	126,497	137,519	148,676

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
75	Chesterfield County Airport	77,015	84,949	98,267	111,685	125,135	138,598	152,110	165,364	178,780
76	East Highland Park	51,525	53,742	57,503	61,324	65,159	68,996	72,853	76,579	80,393
77	Church Hill	24,229	24,092	23,896	23,725	23,558	23,390	23,227	23,017	22,841
78	Ginter Park - Hotchkiss Field	32,739	32,553	32,289	32,058	31,832	31,605	31,384	31,101	30,863
79	Richmond (Downtown-West)	6,266	6,230	6,179	6,135	6,092	6,049	6,006	5,952	5,907
80	Richmond (The Fan District)	38,718	38,498	38,186	37,913	37,646	37,377	37,116	36,781	36,500
81	Richmond (West End)	18,099	17,996	17,850	17,722	17,597	17,472	17,350	17,193	17,062
82	Ashland	14,889	15,963	17,773	19,600	21,433	23,267	25,109	26,907	28,734
83	Goodallr-Farrington	16,451	17,638	19,637	21,656	23,681	25,708	27,743	29,729	31,747
84	Tuckahoe	98,624	102,867	110,067	117,380	124,719	132,064	139,447	146,579	153,880
85	Chester	34,243	37,770	43,692	49,658	55,638	61,624	67,632	73,525	79,490
86	Richmond (Southside)	86,293	85,803	85,107	84,499	83,903	83,304	82,722	81,976	81,349
87	Laurel	117,792	122,859	131,458	140,193	148,959	157,731	166,549	175,067	183,786
88	Powhatan (Rt. 60 & Dorset Rd.)	11,455	12,164	13,359	14,568	15,780	16,993	18,212	19,399	20,607
89	Sabot	10,313	11,196	12,681	14,178	15,679	17,182	18,690	20,167	21,664
90	Richmond International Apt. (Sandston)	33,390	34,826	37,264	39,740	42,225	44,711	47,211	49,625	52,097
91	Mechanicsville (Henry Clay Heights)	69,328	74,331	82,756	91,266	99,800	108,341	116,917	125,289	133,794
92	Sandston (Rt. 156 & Rt. 33)	13,600	14,185	15,178	16,187	17,199	18,212	19,230	20,213	21,220
93	Richmond (Downtown-East)	3,966	3,943	3,911	3,883	3,856	3,829	3,802	3,768	3,739
94	Meadowville - Cameron Hills	5,642	6,223	7,199	8,181	9,167	10,153	11,143	12,114	13,097
95	Robious & Hylton Park	97,106	107,110	123,902	140,820	157,779	174,754	191,790	208,502	225,418
96	Ethridge Estates	5,442	5,499	5,601	5,709	5,818	5,926	6,037	6,135	6,242
97	Fort Lee	15,682	15,846	16,140	16,451	16,764	17,078	17,395	17,679	17,987
98	Rt. 106 & Rt. 156	4,271	4,315	4,395	4,480	4,565	4,651	4,737	4,814	4,898
99	Petersburg (Dinwiddie County Airport - PTB)	11,130	11,203	11,340	11,489	11,639	11,790	11,943	12,073	12,219
100	Petersburg (Blandford)	2,894	2,913	2,948	2,987	3,026	3,065	3,105	3,139	3,177

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
101	Berkley Manor	3,703	3,728	3,773	3,822	3,873	3,923	3,974	4,017	4,066
102	Petersburg (Downtown)	7,945	7,997	8,095	8,201	8,308	8,416	8,525	8,618	8,722
103	Petersburg (Kennelworth)	6,971	7,016	7,102	7,195	7,289	7,383	7,479	7,561	7,652
104	Camelot	4,204	4,232	4,283	4,340	4,396	4,453	4,511	4,560	4,616
105	Petersburg (South)	6,257	6,298	6,375	6,458	6,543	6,627	6,713	6,786	6,869
106	Colonial Heights	12,649	12,732	12,888	13,056	13,227	13,399	13,572	13,720	13,887
107	Colonial Heights (East)	4,830	4,861	4,921	4,985	5,051	5,116	5,182	5,239	5,302
108	Ettrick (Amtrak Petersburg)	9,798	10,807	12,501	14,208	15,919	17,632	19,351	21,037	22,744
109	Hopewell	22,348	22,581	23,000	23,443	23,890	24,337	24,789	25,194	25,633
110	Matoaca	2,059	2,272	2,628	2,987	3,346	3,706	4,068	4,422	4,781
111	Screamersville	10,057	11,093	12,832	14,584	16,340	18,098	19,862	21,593	23,345
112	Pickadat Corner	16,344	18,027	20,853	23,701	26,555	29,412	32,280	35,092	37,939
113	Lake Chesdin Pkwy & Ivey Mill Rd.	7,547	8,324	9,629	10,944	12,262	13,581	14,905	16,204	17,518
118	Dinwiddie	8,652	8,709	8,815	8,931	9,048	9,165	9,284	9,385	9,498
119	Templeton	2,162	2,185	2,225	2,268	2,311	2,354	2,398	2,437	2,480
114	New Kent	16,668	16,745	16,900	17,074	17,253	17,434	17,620	17,761	17,933
115	Sherwood Forest - Rustic	11,034	11,085	11,188	11,303	11,421	11,541	11,664	11,758	11,872
116	Powhatan (Rt. 522 & Three Bridges Rd.)	16,864	16,943	17,099	17,275	17,456	17,639	17,827	17,970	18,144
117	Goochland	11,546	11,600	11,707	11,828	11,952	12,077	12,205	12,304	12,423
120	Dutton	17,482	17,564	17,726	17,909	18,096	18,286	18,481	18,629	18,810
121	Elkton	101,696	106,805	115,447	124,199	132,973	141,746	150,555	159,135	167,870
122	Bristol	49,144	49,592	50,398	51,252	52,111	52,965	53,829	54,611	55,454
123	Warwick	164,843	170,249	179,487	188,920	198,405	207,905	217,472	226,584	236,001
124	Providence	621,939	626,908	635,973	645,625	655,331	664,976	674,727	683,493	692,995
125	Newport	82,036	82,092	82,286	82,553	82,821	83,076	83,340	83,501	83,745
126	Wakefield-Westerly	119,972	123,769	130,263	136,896	143,566	150,246	156,974	163,377	169,998

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
127	Levittown	627,053	644,506	674,400	704,953	735,623	766,280	797,119	826,641	857,081
128	Norristown	808,460	819,872	839,956	860,875	881,930	902,963	924,199	943,808	964,572
129	Philadelphia	1,543,057	1,528,002	1,505,032	1,483,602	1,462,388	1,441,111	1,420,121	1,396,260	1,374,505
130	Springfield-Media	565,648	569,330	576,221	583,690	591,249	598,792	606,463	613,024	620,382
131	Downingtown-Exton	506,575	526,935	561,500	596,607	631,817	667,021	702,387	736,650	771,672
132	Hartford-Glastonbury	897,259	906,080	921,961	938,749	955,672	972,555	989,641	1,005,015	1,021,620
133	Norwich-New London	271,696	274,159	278,622	283,357	288,132	292,893	297,716	302,026	306,705
134	New Haven	859,960	867,413	880,957	895,357	909,876	924,348	939,002	952,075	966,294
135	Middletown	165,602	169,698	176,749	183,983	191,258	198,539	205,874	212,813	220,023
136	Bridgeport	915,683	924,495	940,377	957,177	974,107	990,991	1,008,076	1,023,450	1,040,060
137	Culpeper	47,911	48,135	48,579	49,080	49,593	50,113	50,647	51,054	51,549
138	Fredericksburg	152,991	153,706	155,124	156,722	158,364	160,021	161,729	163,028	164,608
139	Hague	17,524	17,606	17,768	17,951	18,139	18,329	18,525	18,674	18,855
140	Bowling Green	28,972	29,107	29,376	29,679	29,989	30,303	30,627	30,873	31,172
141	Tappahannock	11,233	11,285	11,390	11,507	11,627	11,749	11,875	11,970	12,086
142	Warsaw	9,059	9,101	9,185	9,280	9,377	9,475	9,576	9,653	9,747
143	Heathsville	12,346	12,404	12,518	12,647	12,780	12,913	13,051	13,156	13,283
144	Mattaponi	7,046	7,079	7,144	7,218	7,293	7,370	7,448	7,508	7,581
145	King William	15,981	16,056	16,204	16,371	16,542	16,715	16,894	17,029	17,194
146	Irvington	11,236	11,288	11,393	11,510	11,631	11,752	11,878	11,973	12,089
147	Topping-Deltaville	10,822	10,873	10,973	11,086	11,202	11,319	11,440	11,532	11,644
148	Foster	8,884	8,925	9,008	9,101	9,196	9,292	9,391	9,467	9,559
149	Surry	6,844	6,876	6,939	7,011	7,084	7,158	7,235	7,293	7,364
150	Lunenburg	12,588	12,647	12,764	12,895	13,030	13,166	13,307	13,414	13,544
151	Waverly	11,972	12,028	12,139	12,264	12,392	12,522	12,656	12,757	12,881
152	Lawrenceville	17,010	17,089	17,247	17,425	17,607	17,792	17,981	18,126	18,302
153	Franklin	26,937	27,063	27,313	27,594	27,883	28,175	28,475	28,704	28,982

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
154	Emporia	17,591	17,673	17,836	18,020	18,209	18,399	18,596	18,745	18,927
155	South Mill	31,749	31,897	32,192	32,523	32,864	33,208	33,562	33,832	34,160
156	Wilmington	546,076	553,489	566,564	580,200	593,931	607,645	621,496	634,250	647,783
157	Plymouth-Kingston	474,183	491,653	521,434	551,795	582,321	612,906	643,700	673,099	703,422
158	Taunton	545,999	557,844	578,312	599,368	620,539	641,715	663,053	683,174	704,140
159	Hempstead	1,349,233	1,359,561	1,378,534	1,398,844	1,419,331	1,439,738	1,460,423	1,478,665	1,498,685
160	Brooklyn	2,563,258	2,608,789	2,688,057	2,770,016	2,852,454	2,934,858	3,017,957	3,095,670	3,177,169
161	Yonkers-New Rochelle	931,309	941,266	959,080	977,833	996,725	1,015,574	1,034,633	1,051,924	1,070,487
162	Bronx	1,408,473	1,431,650	1,472,135	1,514,087	1,556,292	1,598,471	1,641,019	1,680,661	1,722,354
163	New York City	1,619,090	1,625,895	1,639,341	1,654,358	1,669,556	1,684,634	1,700,009	1,712,613	1,727,263
164	Staten Island	470,728	490,261	523,451	557,202	591,103	625,048	659,191	692,026	725,731
165	Queens	2,272,771	2,297,336	2,341,253	2,387,463	2,434,011	2,480,457	2,527,417	2,570,057	2,615,804
166	Carmel	99,607	104,188	111,957	119,849	127,773	135,710	143,691	151,383	159,265
167	Spring Valley	317,757	324,611	336,455	348,639	360,890	373,142	385,488	397,132	409,263
168	Dunn	122,135	128,746	139,929	151,260	162,634	174,020	185,463	196,551	207,872
169	Fayetteville	324,049	331,974	345,571	359,475	373,412	387,322	401,307	414,746	428,578
170	Greenville	172,554	183,235	201,278	219,548	237,894	256,271	274,744	292,633	310,899
171	Gatesville	11,869	12,123	12,564	13,018	13,476	13,936	14,400	14,831	15,284
172	Camden	10,090	10,680	11,672	12,672	13,669	14,663	15,659	16,650	17,645
173	Currituck	24,077	25,547	28,017	30,500	32,980	35,450	37,923	40,391	42,866
174	King	46,783	48,337	50,989	53,694	56,412	59,131	61,868	64,488	67,187
175	Jackson	21,428	21,397	21,370	21,359	21,344	21,325	21,305	21,273	21,254
176	Ahoskie	24,438	24,324	24,180	24,075	23,986	23,907	23,843	23,667	23,564
177	Warrenton	20,576	21,006	21,748	22,509	23,270	24,030	24,794	25,526	26,282
178	Henderson	45,132	45,650	46,564	47,516	48,468	49,412	50,362	51,259	52,198
179	Oxford	60,436	62,409	65,772	69,197	72,632	76,067	79,517	82,846	86,260
180	Rosemary	54,006	54,377	55,055	55,775	56,494	57,202	57,915	58,576	59,280

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
181	Elizabeth City	40,591	41,801	43,869	45,981	48,102	50,223	52,357	54,400	56,506
182	Hertford	13,563	13,973	14,675	15,391	16,109	16,829	17,551	18,244	18,958
183	Edenton	14,772	14,908	15,158	15,429	15,707	15,988	16,276	16,512	16,782
184	Yadkinville	38,084	38,907	40,329	41,791	43,261	44,730	46,211	47,609	49,065
185	Franklinton	61,475	64,944	70,809	76,751	82,714	88,685	94,686	100,502	106,439
186	Winston-Salem	358,137	369,671	389,371	409,475	429,668	449,876	470,211	489,668	509,721
187	Greensboro	500,879	508,554	522,003	535,967	550,015	564,050	578,210	591,366	605,235
188	Burlington	153,920	158,178	165,478	172,948	180,452	187,960	195,520	202,719	210,165
189	Chapel Hill	137,941	147,239	162,930	178,807	194,746	210,712	226,754	242,321	258,194
190	Durham	279,641	294,937	320,807	347,020	373,330	399,672	426,143	451,794	477,984
191	Rocky Mount	95,708	98,625	103,604	108,679	113,769	118,855	123,967	128,894	133,950
192	Tarboro	55,954	56,247	56,796	57,388	57,978	58,557	59,139	59,671	60,247
193	Raleigh	952,151	1,019,686	1,133,599	1,248,823	1,364,502	1,480,387	1,596,834	1,709,855	1,825,071
194	Mocksville	41,433	43,189	46,172	49,203	52,248	55,296	58,361	61,313	64,340
195	Lexington	163,260	168,232	176,734	185,419	194,143	202,873	211,658	220,051	228,712
196	Manteo	34,573	35,602	37,361	39,157	40,961	42,765	44,580	46,318	48,109
197	Asheboro	142,466	145,107	149,697	154,436	159,201	163,964	168,766	173,270	177,983
198	Siler City	65,976	70,418	77,913	85,498	93,111	100,737	108,401	115,837	123,419
199	Wilson	81,867	83,161	85,410	87,731	90,054	92,366	94,691	96,908	99,207
200	Salisbury	138,180	142,107	148,806	155,629	162,460	169,273	176,115	182,757	189,546
201	Smithfield	174,938	187,273	208,082	229,130	250,262	271,431	292,702	313,347	334,394
202	Lincolnton	79,313	82,956	89,128	95,390	101,671	107,955	114,268	120,388	126,639
203	Charlotte	969,031	1,028,333	1,128,528	1,230,001	1,331,885	1,433,935	1,536,500	1,635,849	1,737,282
204	Concord	184,498	199,744	225,448	251,446	277,567	303,754	330,080	355,567	381,582
205	Gastonia	208,049	213,785	223,576	233,550	243,533	253,490	263,487	273,193	283,115
206	Monroe	208,520	224,524	251,519	278,832	306,268	333,771	361,417	388,184	415,507
207	Hickory	154,339	158,641	165,984	173,462	180,949	188,416	195,914	203,193	210,634

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
208	Southern Pines	90,302	94,082	100,497	107,013	113,552	120,092	126,666	133,022	139,525
209	Raeford-Silver City	50,536	53,308	57,995	62,745	67,512	72,285	77,081	81,729	86,475
210	Sanford	59,715	62,177	66,358	70,605	74,865	79,127	83,411	87,553	91,791
211	Sussex	147,442	153,385	163,490	173,770	184,095	194,433	204,834	214,828	225,092
212	Paterson	502,885	505,269	509,896	515,013	520,187	525,326	530,559	534,923	539,927
213	Paramus	918,888	922,012	928,411	935,698	943,083	950,397	957,875	963,801	970,877
214	Phillipsburg	107,653	110,912	116,489	122,186	127,911	133,640	139,408	144,910	150,593
215	Parsippany Troy Hills	497,999	507,517	524,039	541,088	558,234	575,376	592,658	608,873	625,835
216	Newark	787,744	786,083	784,331	783,313	782,358	781,320	780,396	778,265	777,053
217	Jersey City-Hoboken	647,578	651,560	659,038	667,151	675,345	683,496	691,774	698,908	706,879
218	Flemington	127,050	131,997	140,414	148,980	157,585	166,201	174,867	183,190	191,743
219	Bridgewater-Somerville	327,707	338,615	357,233	376,227	395,309	414,409	433,632	452,020	470,971
220	Elizabeth	543,976	546,177	550,552	555,454	560,417	565,338	570,360	574,452	579,231
221	New Brunswick	811,493	833,235	870,554	908,768	947,173	985,601	1,024,296	1,061,076	1,099,168
222	Trenton	368,303	375,407	387,734	400,451	413,240	426,026	438,916	451,016	463,669
223	Willingboro	449,199	459,083	476,141	493,667	511,274	528,870	546,589	563,382	580,825
224	Camden	515,676	520,447	529,085	538,251	547,502	556,737	566,095	574,430	583,496
225	Woodbury	289,586	301,020	320,439	340,167	359,953	379,735	399,611	418,857	438,536
226	Penns Grove-Carneys Point	65,774	66,741	68,439	70,205	71,981	73,757	75,549	77,208	78,962
227	Lawrence	725,139	740,500	767,062	794,401	821,890	849,382	877,087	903,192	930,410
228	Cambridge - Burlington	1,537,215	1,546,416	1,563,678	1,582,360	1,601,150	1,619,763	1,638,611	1,655,166	1,673,462
229	Worcester	806,163	824,054	854,946	886,709	918,645	950,592	982,783	1,013,157	1,044,790
230	Boston	743,661	747,958	756,050	764,828	773,657	782,399	791,253	799,005	807,596
231	Quincy	651,798	659,980	674,455	689,572	704,775	719,935	735,235	749,361	764,339
232	Alexandria (Old Town)	58,564	59,435	60,915	62,433	63,988	65,458	67,339	68,731	70,337
233	Metro-Ballston Station	176,033	179,159	185,194	187,293	189,311	189,401	189,421	193,225	193,637
234	Downtown	36,530	36,986	37,449	37,828	39,894	43,510	46,042	46,838	49,447
235	Johns Hopkins Hospital	281,854	285,367	288,943	291,869	292,044	291,676	292,580	294,857	295,129

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
236	Brooklyn Manor	14,252	14,429	14,610	14,758	14,579	14,511	14,472	14,533	14,446
237	South Baltimore - Locust Point	8,976	9,087	9,201	9,294	9,262	9,478	9,606	9,660	9,761
238	Druid Hill Park - Mondawmin Mall	279,731	283,217	286,766	289,670	291,123	292,347	294,431	297,019	298,570
239	The National Mall	12,212	13,546	14,472	16,586	17,894	19,490	20,263	22,037	23,502
240	Capitol Hill - Union Station	80,082	84,409	91,922	108,280	111,229	114,853	119,414	129,694	135,154
241	Washington Hospital Center	77,210	82,648	88,782	95,622	100,236	105,873	110,087	116,517	121,624
242	Wesley Heights	78,771	79,885	82,316	83,377	84,869	86,676	90,123	91,118	93,019
243	Brightwood	43,119	43,768	46,556	47,061	47,594	48,246	50,168	50,993	51,652
244	Congress Heights	85,572	86,898	94,515	97,607	100,408	103,758	107,890	112,062	114,900
245	Capital View	61,554	63,750	66,415	67,420	71,287	75,968	78,994	81,514	85,090
246	Chevy Chase	26,880	26,999	27,071	27,650	28,083	28,612	29,745	29,906	30,610
247	Downtown DC	36,792	37,322	40,303	42,151	42,707	43,381	45,094	46,692	47,533
248	Logan Circle	130,130	133,939	139,897	143,125	145,051	147,356	153,219	155,835	158,642
249	Pentagon	45,012	46,572	51,571	53,806	54,611	54,977	56,817	59,283	59,973
250	Landmark - Van Dorn	87,730	89,075	91,364	93,712	96,120	100,583	103,841	106,171	109,520
251	Prince Frederick	89,628	92,385	96,165	98,847	100,616	102,414	104,238	107,089	108,821
252	Westminster	108,838	112,303	118,051	122,753	127,675	132,172	136,758	141,908	146,466
253	Eldersburg	58,379	59,681	61,408	62,979	64,842	65,858	66,895	68,739	70,062
254	Charlotte Hall (Peninsula) - Hughesville	29,469	31,274	34,260	36,569	37,903	39,250	40,608	42,941	44,275
255	Waldorf	87,506	93,964	104,679	115,494	122,942	130,420	137,932	148,023	155,733
256	Marbury-Pomonkey	33,617	34,838	36,841	38,891	40,705	42,524	44,347	46,332	48,171
257	Lexington Park	108,987	116,748	128,501	139,413	149,634	160,662	172,516	183,133	193,993
258	Bethesda	112,391	119,948	122,699	124,956	124,974	125,325	125,386	127,390	127,631
259	Silver Spring	84,989	91,045	92,678	92,616	92,297	91,817	92,785	92,786	92,553
260	Wheaton	178,431	181,481	187,692	188,863	189,547	190,176	190,849	193,599	193,733
261	Rockville	114,714	121,284	138,660	150,311	158,150	165,132	170,893	184,268	190,912

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
262	Potomac	73,667	74,169	74,253	74,687	74,965	76,058	76,887	77,098	77,850
263	Gaithersburg - Germantown	208,580	213,223	224,180	241,222	258,740	268,592	273,984	292,112	304,585
264	Olney	137,219	137,353	139,544	139,927	140,267	139,404	138,933	140,020	139,536
265	Damascus-Clarksburg	42,886	49,458	57,695	62,385	63,788	64,688	64,310	70,051	70,665
266	Dawsonville	50,158	50,126	50,220	50,033	50,215	50,603	50,611	50,677	50,833
267	Hyattsville (Chillum)	71,025	70,991	70,693	71,261	71,984	72,589	72,950	73,366	74,044
268	College Park	82,834	85,364	88,659	91,792	95,180	97,522	98,793	102,598	105,062
269	Hyattsville (Edmonston)	31,410	31,418	32,517	33,845	34,080	34,228	34,188	35,301	35,536
270	Lanham (Landover Hills)	41,563	41,355	42,761	43,343	44,009	44,201	44,151	45,200	45,426
271	Fairmount Heights	25,019	24,897	25,144	25,482	25,707	25,854	25,834	26,190	26,346
272	Glenarden	25,881	26,198	26,400	26,503	26,957	27,283	27,311	27,642	27,912
273	District Heights	47,770	47,683	47,938	48,102	48,003	48,052	48,019	48,159	48,136
274	Marlow Heights	85,530	85,506	86,453	87,746	88,407	89,011	89,035	90,291	90,857
275	Upper Marlboro	55,761	58,654	64,352	69,912	75,097	78,961	81,799	87,936	92,087
276	Beltsville	92,591	94,170	96,207	97,019	97,604	99,002	100,475	101,462	102,432
277	NASA Goddard Space Flight Center	34,961	35,185	35,241	35,183	35,668	35,957	36,014	36,219	36,481
278	Bowie	63,263	63,819	64,136	64,243	65,247	66,142	66,548	67,089	67,825
279	Woodmore	52,432	52,780	54,120	55,543	56,237	56,919	57,093	58,514	59,134
280	Cheltenham	59,447	61,384	63,686	64,849	67,493	70,240	71,108	73,553	75,574
281	Fort Washington	113,326	119,565	125,785	130,028	134,275	137,986	140,763	146,084	149,562
282	Severn	41,995	42,457	43,286	44,070	44,568	45,052	45,052	45,958	46,343
283	Odenton	28,487	29,092	29,906	30,617	31,966	32,255	32,255	33,437	34,025
284	Crofton	43,909	45,748	46,290	46,440	46,800	47,310	47,310	47,773	48,040
285	Crownsville	20,992	21,230	21,621	21,951	21,984	22,187	22,187	22,512	22,611
286	Davidsonville	13,647	13,665	13,738	13,758	13,759	13,907	13,907	13,961	14,010
287	Galesville	63,466	63,714	64,324	64,908	65,430	66,145	66,145	66,924	67,388
288	Riviera Beach	70,030	71,307	72,895	74,677	75,802	76,625	76,625	78,546	79,354

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
290	Pasadena (Millersville)	67,459	68,022	69,163	69,917	70,196	70,961	70,961	71,907	72,280
291	Linthicum Heights	23,495	24,233	24,601	25,090	25,360	25,615	25,615	26,108	26,334
292	Glenmore	48,740	48,922	49,527	50,205	50,481	51,033	51,033	51,735	52,076
293	Baltimore Washington International Airport	18	18	18	19	19	19	19	19	19
294	Fort Meade-Patuxent Research Refuge	26,050	26,376	26,852	27,353	28,289	28,623	28,623	29,435	29,902
295	Hanover	13,676	14,834	16,842	18,111	19,794	20,103	20,103	22,079	22,752
296	Edgewood	85,793	89,129	92,615	93,877	94,475	95,386	102,361	102,148	104,213
297	Bel Air	104,027	107,469	110,631	110,953	110,407	110,013	117,461	115,912	117,116
298	Aberdeen	58,802	61,646	65,340	67,927	70,192	72,485	77,091	79,206	81,952
299	Catonsville - Halethorpe	112,718	113,462	115,037	116,519	117,318	117,737	120,124	120,921	122,008
300	Randallstown	124,361	125,921	127,631	129,099	129,844	130,323	135,301	135,258	136,965
301	Reisterstown	65,274	67,385	68,315	69,130	69,609	69,863	75,786	74,727	76,467
302	Brooklandville	58,488	58,928	59,677	60,338	60,638	60,870	63,581	63,386	64,266
303	Towson	160,230	161,999	164,547	166,315	167,157	167,732	171,755	172,502	174,002
304	Hereford	33,311	33,679	34,313	34,793	35,093	35,227	36,808	36,854	37,403
305	Perry Hall	62,016	63,062	64,152	64,976	65,496	65,745	69,578	69,290	70,514
306	Rosedale-Rossville	201,056	203,636	206,662	209,043	210,278	211,077	217,127	217,831	220,092
307	Frederick	170,776	180,674	196,977	213,972	237,983	264,266	293,028	309,915	335,504
308	Thurmont	68,806	71,906	76,893	81,312	85,330	89,729	94,542	98,856	103,167
309	Sterling	156,548	161,350	171,007	178,296	181,369	183,384	186,121	193,327	195,960
310	Ashburn South	65,444	77,485	106,791	127,026	133,657	137,494	139,891	161,467	165,969
311	Leesburg	80,504	84,449	97,195	107,273	115,530	120,649	122,327	134,705	140,063
312	Purcellville	34,402	36,664	43,505	51,161	55,473	59,375	61,732	69,045	73,047
313	Herndon - Reston	181,731	187,662	196,953	205,374	212,393	217,619	224,128	232,490	238,743
314	Centreville	166,837	172,379	185,568	198,180	208,731	216,409	223,508	236,668	245,427
315	Fairfax	147,772	149,352	151,354	152,628	153,799	155,276	159,883	160,274	162,320

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
316	Vienna	96,854	102,091	105,503	108,299	110,697	112,544	117,223	119,311	122,028
317	Seven Corners	115,458	117,566	121,048	124,294	127,182	129,360	133,540	136,268	139,217
318	Springfield	155,228	157,722	162,401	166,322	169,543	172,110	178,755	181,560	185,348
319	Huntington	206,289	213,315	223,607	232,807	240,590	246,513	254,843	263,693	270,922
320	McLean	69,921	73,087	77,326	81,039	84,205	86,574	90,754	94,089	97,197
321	Great Falls	15,202	15,304	15,492	15,678	15,833	15,946	17,181	16,996	17,401
322	Warrenton	66,542	72,435	83,452	96,156	110,805	127,685	147,136	158,364	175,037
323	Dale City	250,649	263,858	280,288	293,796	306,016	315,908	323,713	339,099	349,173
324	Manassas	134,018	138,917	149,154	157,262	164,373	170,732	176,368	185,378	191,691
325	Haymarket	102,025	109,547	120,418	130,941	138,924	145,756	151,346	162,121	169,241
326	Stafford	134,352	147,866	167,501	187,129	206,280	225,429	246,358	265,299	284,915
327	200-KGC01-King George	24,500	26,071	29,427	32,780	36,176	39,569	43,283	46,539	50,009
328	Columbia	103,346	103,371	102,497	101,628	102,025	102,025	102,025	101,487	101,563
329	Ellicott City	65,393	66,141	68,800	68,727	68,727	68,730	68,730	69,583	69,276
330	Elkridge	41,868	44,817	49,076	50,050	50,722	50,722	50,722	52,865	52,789
331	Peninsula Laurel-Savage	39,503	40,827	43,439	47,349	49,672	51,164	51,164	54,987	56,697
332	Clarksville	18,359	20,176	21,054	21,433	22,490	23,099	23,099	24,073	24,612
333	Cooksville	30,961	32,725	34,428	35,565	36,881	38,305	38,305	40,120	41,077

1.2 STUDY AREA EMPLOYMENT DATA AND FORECASTS

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
1	Norfolk (Downtown)	32,375	33,058	34,227	35,438	36,692	37,989	39,118	40,336	41,558
2	Lamberts Point - Colonial Place	7,841	7,860	7,891	7,922	7,953	7,985	8,015	8,047	8,078
3	Fairmount Park - Lafayette Annex	2,790	2,808	2,838	2,869	2,900	2,931	2,961	2,992	3,023
4	Glenwood Park	65,593	64,647	63,100	61,589	60,115	58,677	57,095	55,589	54,087
5	Norfolk International Airport	11,420	11,492	11,613	11,735	11,859	11,983	12,103	12,225	12,347
6	Virginia Beach	28,511	28,850	29,425	30,011	30,609	31,219	31,783	32,371	32,961
7	Chinese Corner	57,429	57,883	58,649	59,425	60,211	61,008	61,764	62,542	63,320
8	Oceana Naval Air Station	24,729	24,691	24,628	24,565	24,502	24,439	24,375	24,312	24,249
9	Berkley - Campostella	6,545	6,378	6,109	5,852	5,605	5,369	5,089	4,833	4,578
10	Portsmouth	33,173	33,061	32,876	32,691	32,508	32,326	32,139	31,955	31,771
11	Victory Park	9,673	9,521	9,273	9,032	8,797	8,568	8,314	8,074	7,834
12	Arostead Forest - Craney Island	6,053	6,207	6,474	6,752	7,042	7,345	7,600	7,880	8,162
13	Bowers Hill	6,845	7,129	7,629	8,165	8,738	9,351	9,816	10,358	10,904
14	Boone	13,095	13,558	14,366	15,222	16,130	17,091	17,851	18,716	19,587
15	Loxley Gardens - Geneva Park	6,671	6,724	6,813	6,903	6,995	7,087	7,175	7,266	7,356
16	South Norfolk	8,989	9,256	9,719	10,205	10,716	11,252	11,692	12,183	12,676
17	1200 Battlefield Blvd N	10,742	11,028	11,521	12,037	12,576	13,139	13,610	14,130	14,652
18	910 Great Bridge Blvd	5,735	5,908	6,207	6,521	6,851	7,198	7,482	7,799	8,118
19	Chesapeake	14,258	15,320	17,267	19,461	21,934	24,722	26,409	28,660	30,941
20	Bennett Corner	9,417	10,957	14,102	18,151	23,362	30,068	32,126	36,498	40,985
21	Suffolk	18,802	19,703	21,303	23,032	24,902	26,923	28,391	30,145	31,915
22	Holland	1,090	1,097	1,107	1,117	1,128	1,139	1,149	1,160	1,170
23	Kings Fork	6,774	7,945	10,363	13,517	17,631	22,997	24,514	27,942	31,465
24	Smithfield	11,288	12,014	13,329	14,789	16,408	18,204	19,370	20,861	22,369
25	Zuni	4,865	5,434	6,534	7,857	9,448	11,361	12,212	13,600	15,015

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
26	Newport News (Downtown South)	8,188	8,508	9,070	9,670	10,309	10,990	11,516	12,122	12,733
27	Newport News Amtrak Station	3,210	3,175	3,118	3,062	3,007	2,952	2,894	2,838	2,782
28	Newport News (Downtown Peninsula)	22,867	23,011	23,253	23,498	23,745	23,995	24,235	24,480	24,725
29	Newport News (Reed)	1,426	1,425	1,423	1,421	1,420	1,418	1,416	1,414	1,413
30	Glendale - Beaconsville	16,646	16,586	16,485	16,386	16,286	16,188	16,087	15,987	15,888
31	Charles	2,305	2,406	2,584	2,775	2,980	3,201	3,366	3,559	3,755
32	Sunsan Constant Dr	5,548	5,671	5,883	6,102	6,329	6,565	6,769	6,989	7,210
33	2 Shore Park Dr	11,205	10,860	10,309	9,786	9,290	8,819	8,242	7,722	7,205
34	Hampton (West)	12,322	12,392	12,511	12,631	12,751	12,873	12,991	13,110	13,230
35	Hampton (Downtown)	6,675	6,726	6,811	6,898	6,986	7,075	7,160	7,247	7,334
36	Fox Corner	5,015	5,049	5,106	5,163	5,221	5,280	5,336	5,394	5,452
37	Chapel Village	11,904	12,019	12,214	12,412	12,614	12,818	13,010	13,208	13,407
38	Poquoson	3,342	3,419	3,550	3,686	3,827	3,974	4,101	4,238	4,375
39	Yorktown (Rt. 134 & Rt. 600)	2,719	2,801	2,943	3,092	3,249	3,414	3,548	3,699	3,850
40	Yorktown (West)	9,020	9,315	9,828	10,369	10,940	11,542	12,027	12,574	13,123
41	Greensprings-Plantation Heights	4,034	4,119	4,264	4,414	4,570	4,732	4,872	5,023	5,175
42	Skimino	2,579	2,926	3,610	4,453	5,494	6,779	7,279	8,173	9,087
43	Charleston Heights - York Terrace	6,194	6,630	7,426	8,317	9,316	10,434	11,130	12,043	12,967
44	Williamsburg	19,215	19,233	19,263	19,293	19,322	19,352	19,382	19,411	19,441
45	Williamsburg (Southeast - Forest Hill Park)	6,031	6,449	7,210	8,062	9,015	10,080	10,748	11,620	12,503
46	James Terrace - Grove	12,906	13,653	14,996	16,471	18,091	19,871	21,078	22,581	24,099
47	Jamestown - Hollybrook	3,866	3,917	4,004	4,092	4,182	4,275	4,359	4,448	4,537
48	Canterbury Hills - Jamestown Farms	12,631	13,286	14,455	15,727	17,110	18,616	19,680	20,972	22,277
49	Toano	3,809	4,400	5,595	7,114	9,046	11,502	12,311	13,943	15,615
50	Gloucester	14,798	15,382	16,407	17,500	18,667	19,911	20,867	21,973	23,087

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
51	Grassfield - Chesapeake Regional Apt.	3,189	3,838	5,226	7,116	9,690	13,196	13,938	16,039	18,206
52	Gent-Park Place	21,559	21,682	21,888	22,096	22,307	22,519	22,723	22,932	23,141
53	Huntersville (Hunter's Village)	3,590	3,598	3,613	3,627	3,641	3,656	3,670	3,684	3,699
54	Ocean View - Willoughby Beach	2,675	2,670	2,662	2,654	2,646	2,638	2,630	2,622	2,614
55	Sussex - Wards Corner	6,868	6,873	6,883	6,892	6,902	6,911	6,921	6,930	6,940
56	Thomas Corner	48,781	49,002	49,371	49,744	50,119	50,497	50,864	51,237	51,610
57	London Bridge	40,844	41,765	43,346	44,987	46,690	48,458	49,980	51,631	53,289
58	Nimmo-Woodhouse Corner	16,622	17,088	17,894	18,738	19,622	20,547	21,316	22,166	23,021
59	Westhaven Park	8,317	8,136	7,844	7,563	7,291	7,029	6,727	6,447	6,167
60	Hawthorne Drive, Chesapeake	16,899	16,993	17,152	17,312	17,473	17,636	17,793	17,953	18,114
61	Shenandoah Pkwy	33,346	34,328	36,031	37,818	39,694	41,662	43,281	45,083	46,894
62	St. Brides	5,400	5,672	6,156	6,681	7,251	7,870	8,312	8,845	9,383
63	Deer Park - Harpersville	23,553	24,310	25,626	27,014	28,476	30,018	31,264	32,664	34,072
64	Newport News/Williamsburg International Airport	21,458	22,233	23,588	25,024	26,549	28,166	29,438	30,890	32,351
65	Hampton (East)	7,385	7,361	7,319	7,278	7,238	7,197	7,156	7,115	7,074
66	504 E Mercury Blvd	8,214	8,248	8,304	8,361	8,418	8,475	8,531	8,588	8,644
67	Greenwood Farms	1,734	1,730	1,722	1,714	1,706	1,698	1,690	1,682	1,674
68	Drummonds Corner	24,391	24,435	24,510	24,585	24,660	24,735	24,810	24,885	24,960
69	Yorktown - Grafton	9,309	9,525	9,896	10,281	10,681	11,097	11,454	11,841	12,230
70	Pecan Gardens	52,096	52,731	53,808	54,907	56,028	57,172	58,228	59,330	60,434
71	Acredale	21,691	21,729	21,791	21,854	21,917	21,980	22,042	22,105	22,168
72	Woodhaven Shores - New Kent Co. Airport	5,655	5,895	6,307	6,712	7,116	7,518	7,912	8,305	8,717
73	Charles City	2,555	2,717	3,011	3,334	3,689	4,076	4,505	4,741	5,091
74	Swift Creek Resevoir	14,597	15,934	18,406	21,211	24,385	27,964	31,992	33,818	36,932
75	Chesterfield County Airport	31,231	34,092	39,382	45,384	52,175	59,833	68,450	72,358	79,020

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
76	East Highland Park	13,618	14,536	16,174	17,954	19,882	21,965	24,213	25,578	27,485
77	Church Hill	2,611	2,624	2,648	2,678	2,719	2,774	2,844	2,843	2,886
78	Ginter Park - Hotchkiss Field	11,695	11,750	11,856	11,995	12,179	12,421	12,737	12,733	12,926
79	Richmond (Downtown-West)	31,458	31,605	31,892	32,265	32,759	33,412	34,261	34,249	34,770
80	Richmond (The Fan District)	36,987	37,160	37,498	37,936	38,517	39,285	40,283	40,269	40,881
81	Richmond (West End)	8,707	8,747	8,827	8,930	9,067	9,247	9,482	9,479	9,623
82	Ashland	7,606	7,926	8,461	8,995	9,525	10,048	10,561	11,092	11,625
83	Goodallr-Farrington	2,277	2,373	2,533	2,693	2,852	3,008	3,162	3,321	3,480
84	Tuckahoe	77,134	82,333	91,612	101,692	112,611	124,413	137,147	144,879	155,676
85	Chester	21,971	23,984	27,705	31,928	36,705	42,093	48,155	50,905	55,591
86	Richmond (Southside)	38,960	39,142	39,498	39,959	40,571	41,380	42,431	42,417	43,062
87	Laurel	97,087	103,632	115,310	127,998	141,742	156,598	172,625	182,358	195,947
88	Powhatan (Rt. 60 & Dorset Rd.)	10,252	10,629	11,237	11,816	12,365	12,872	13,335	13,961	14,530
89	Sabot	20,043	21,633	24,530	27,764	31,365	35,365	39,796	42,039	45,585
90	Richmond International Apt. (Sandston)	21,592	23,048	25,645	28,467	31,523	34,827	38,392	40,556	43,579
91	Mechanicsville (Henry Clay Heights)	50,112	52,222	55,747	59,269	62,761	66,206	69,588	73,083	76,599
92	Sandston (Rt. 156 & Rt. 33)	4,374	4,669	5,195	5,766	6,385	7,055	7,777	8,215	8,827
93	Richmond (Downtown-East)	36,568	36,739	37,073	37,506	38,080	38,840	39,826	39,813	40,418
94	Meadowville - Cameron Hills	21,549	23,523	27,173	31,315	36,000	41,284	47,230	49,927	54,523
95	Robious & Hylton Park	82,207	89,738	103,660	119,459	137,334	157,491	180,173	190,461	207,997
96	Ethridge Estates	3,163	3,224	3,336	3,460	3,599	3,755	3,929	4,012	4,150
97	Fort Lee	7,513	7,660	7,926	8,220	8,550	8,919	9,335	9,530	9,860
98	Rt. 106 & Rt. 156	3,048	3,108	3,215	3,335	3,469	3,619	3,787	3,867	4,000
99	Petersburg (Dinwiddie County Airport - PTB)	5,975	6,079	6,252	6,424	6,595	6,765	6,936	7,097	7,273
100	Petersburg (Blandford)	1,421	1,445	1,487	1,527	1,568	1,609	1,649	1,688	1,729
101	Berkley Manor	1,494	1,520	1,563	1,606	1,649	1,691	1,734	1,774	1,818

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
102	Petersburg (Downtown)	5,949	6,053	6,225	6,396	6,567	6,736	6,906	7,067	7,242
103	Petersburg (Kennelworth)	1,809	1,841	1,893	1,945	1,997	2,048	2,100	2,149	2,202
104	Camelot	238	242	249	256	263	270	276	283	290
105	Petersburg (South)	4,371	4,447	4,573	4,699	4,824	4,949	5,074	5,192	5,321
106	Colonial Heights	4,733	4,815	4,952	5,088	5,224	5,359	5,494	5,622	5,761
107	Colonial Heights (East)	5,112	5,201	5,349	5,496	5,643	5,788	5,934	6,073	6,223
108	Ettrick (Amtrak Petersburg)	32,546	35,527	41,039	47,294	54,371	62,351	71,331	75,404	82,346
109	Hopewell	17,520	17,861	18,482	19,169	19,938	20,799	21,768	22,224	22,992
110	Matoaca	14,385	15,703	18,139	20,904	24,032	27,559	31,528	33,328	36,397
111	Screamersville	84,769	92,534	106,891	123,182	141,613	162,399	185,788	196,397	214,479
112	Pickadat Corner	38,149	41,644	48,105	55,436	63,731	73,085	83,611	88,385	96,523
113	Lake Chesdin Pkwy & Ivey Mill Rd.	1,707	1,863	2,153	2,481	2,852	3,270	3,741	3,955	4,319
118	Dinwiddie	7,752	7,887	8,111	8,334	8,557	8,777	8,999	9,208	9,437
119	Templeton	3,026	3,085	3,193	3,311	3,444	3,593	3,760	3,839	3,972
114	New Kent	5,655	5,895	6,307	6,712	7,116	7,518	7,912	8,305	8,717
115	Sherwood Forest - Rustic	2,555	2,717	3,011	3,334	3,689	4,076	4,505	4,741	5,091
116	Powhatan (Rt. 522 & Three Bridges Rd.)	10,252	10,629	11,237	11,816	12,365	12,872	13,335	13,961	14,530
117	Goochland	20,043	21,633	24,530	27,764	31,365	35,365	39,796	42,039	45,585
120	Dutton	14,680	15,546	17,069	18,675	20,360	22,117	23,930	25,292	26,968
121	Elkton	40,425	41,970	44,709	47,683	50,926	54,480	58,390	60,633	63,870
122	Bristol	22,361	23,022	24,186	25,429	26,762	28,175	29,680	30,722	32,047
123	Warwick	96,370	99,577	105,149	111,022	117,219	123,759	130,671	135,766	141,963
124	Providence	343,955	350,560	362,386	375,279	389,293	404,483	420,902	430,720	444,723
125	Newport	53,833	55,135	57,391	59,752	62,233	64,850	67,613	69,575	72,089
126	Wakefield-Westerly	75,747	79,360	85,807	92,830	100,509	108,907	118,122	123,490	131,107
127	Levittown	365,735	376,089	394,136	413,070	432,800	453,228	474,265	491,574	510,990
128	Norristown	607,136	625,456	657,386	690,896	725,817	761,954	799,122	829,260	863,816

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
129	Philadelphia	780,468	828,888	917,099	1,015,357	1,124,445	1,245,170	1,378,358	1,446,499	1,554,775
130	Springfield-Media	289,389	295,372	305,646	316,259	327,149	338,269	349,573	359,422	370,351
131	Downingtown-Exton	337,476	348,918	368,978	390,219	412,578	435,988	460,396	478,719	500,882
132	Hartford-Glastonbury	629,593	649,136	682,598	717,116	752,601	788,966	826,129	856,529	892,330
133	Norwich-New London	168,852	176,702	190,653	205,728	221,945	239,323	257,856	269,243	285,511
134	New Haven	483,124	495,871	518,599	543,286	570,048	598,990	630,217	649,145	675,827
135	Middletown	93,993	98,572	106,742	115,617	125,210	135,535	146,621	153,444	162,931
136	Bridgeport	609,378	620,455	639,330	658,735	678,664	699,091	719,997	738,638	758,658
137	Culpeper	21,907	23,127	25,291	27,644	30,210	33,010	36,078	37,884	40,406
138	Fredericksburg	77,947	82,883	91,668	101,194	111,497	122,618	134,587	142,040	152,179
139	Hague	6,259	6,505	6,928	7,356	7,792	8,236	8,683	9,099	9,528
140	Bowling Green	10,546	10,970	11,678	12,379	13,072	13,744	14,393	15,095	15,796
141	Tappahannock	5,605	5,739	5,939	6,122	6,285	6,424	6,541	6,786	6,947
142	Warsaw	4,003	4,051	4,129	4,209	4,291	4,375	4,461	4,552	4,626
143	Heathsville	4,592	4,732	4,980	5,245	5,523	5,811	6,110	6,347	6,614
144	Mattaponi	2,513	2,571	2,667	2,760	2,851	2,936	3,018	3,113	3,206
145	King William	5,030	5,111	5,240	5,361	5,467	5,568	5,652	5,791	5,905
146	Irvington	7,295	7,492	7,811	8,118	8,403	8,666	8,909	9,262	9,547
147	Topping-Deltaville	5,182	5,369	5,678	5,982	6,277	6,559	6,828	7,148	7,444
148	Foster	4,863	5,091	5,477	5,872	6,267	6,670	7,067	7,438	7,837
149	Surry	3,200	3,305	3,478	3,649	3,818	3,989	4,151	4,322	4,495
150	Lunenburg	4,149	4,251	4,401	4,558	4,705	4,843	4,974	5,145	5,290
151	Waverly	4,400	4,455	4,550	4,640	4,721	4,803	4,875	4,961	5,054
152	Lawrenceville	6,178	6,360	6,674	7,001	7,328	7,664	8,003	8,292	8,625
153	Franklin	11,729	12,032	12,548	13,075	13,615	14,172	14,746	15,220	15,766
154	Emporia	9,973	10,203	10,562	10,877	11,151	11,387	11,584	12,005	12,287
155	South Mill	16,707	17,048	17,663	18,349	19,113	19,959	20,894	21,425	22,152
156	Wilmington	348,757	361,731	384,839	410,021	437,575	467,826	501,148	519,806	547,311

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
157	Plymouth-Kingston	261,292	270,321	286,040	302,611	320,086	338,500	357,894	372,480	389,836
158	Taunton	271,133	277,670	289,290	301,870	315,490	330,220	346,140	356,374	369,648
159	Hempstead	819,105	837,327	868,665	901,213	934,956	969,885	1,005,980	1,035,506	1,069,662
160	Brooklyn	799,939	834,622	896,632	964,369	1,038,435	1,119,487	1,208,262	1,259,561	1,332,699
161	Yonkers-New Rochelle	572,029	586,189	610,355	635,227	660,823	687,137	714,148	736,854	762,966
162	Bronx	360,718	372,582	393,388	415,581	439,264	464,548	491,551	509,763	533,366
163	New York City	2,799,075	2,893,376	3,056,119	3,226,031	3,403,350	3,588,296	3,781,070	3,931,516	4,109,691
164	Staten Island	145,713	150,621	159,153	168,147	177,629	187,628	198,172	206,047	215,494
165	Queens	765,494	788,470	828,673	871,445	917,026	965,657	1,017,598	1,054,307	1,099,107
166	Carmel	40,573	42,211	45,078	48,122	51,357	54,801	58,473	60,996	64,243
167	Spring Valley	153,710	156,495	161,306	166,326	171,567	177,045	182,760	187,232	192,552
168	Dunn	42,409	44,997	49,647	54,735	60,298	66,370	72,997	76,803	82,284
169	Fayetteville	207,089	214,966	228,696	243,226	258,632	274,969	292,313	303,900	319,444
170	Greenville	89,350	95,589	106,863	119,314	133,044	148,151	164,753	173,392	187,102
171	Gatesville	2,543	2,615	2,731	2,840	2,948	3,043	3,130	3,244	3,356
172	Camden	3,922	4,076	4,339	4,608	4,878	5,148	5,411	5,678	5,942
173	Currituck	9,158	9,668	10,548	11,464	12,416	13,399	14,414	15,223	16,170
174	King	12,706	13,115	13,830	14,589	15,397	16,257	17,171	17,771	18,588
175	Jackson	7,261	7,541	8,034	8,562	9,122	9,716	10,347	10,756	11,321
176	Ahoskie	11,528	11,849	12,409	13,002	13,640	14,327	15,076	15,511	16,166
177	Warrenton	4,989	5,087	5,262	5,442	5,628	5,823	6,032	6,163	6,362
178	Henderson	18,647	19,183	20,116	21,112	22,171	23,309	24,535	25,372	26,410
179	Oxford	25,163	26,016	27,513	29,121	30,854	32,729	34,768	36,002	37,733
180	Rosemary	22,406	23,107	24,306	25,553	26,842	28,182	29,572	30,596	31,922
181	Elizabeth City	22,416	23,212	24,538	25,843	27,100	28,305	29,442	30,791	32,071
182	Hertford	3,805	3,895	4,046	4,202	4,364	4,527	4,695	4,839	4,998
183	Edenton	7,048	7,218	7,507	7,810	8,127	8,466	8,827	9,059	9,390
184	Yadkinville	13,993	14,522	15,425	16,376	17,366	18,393	19,468	20,271	21,271

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
185	Franklinton	22,641	23,790	25,919	28,373	31,211	34,521	38,398	39,881	42,649
186	Winston-Salem	223,313	233,742	252,206	272,087	293,462	316,389	340,919	356,324	377,704
187	Greensboro	332,239	342,702	360,764	379,640	399,373	420,003	441,585	457,774	477,565
188	Burlington	78,290	81,088	86,098	91,593	97,650	104,358	111,821	115,832	121,815
189	Chapel Hill	80,290	85,419	94,565	104,471	115,164	126,657	138,962	146,314	157,071
190	Durham	235,940	252,979	283,796	317,897	355,595	397,205	443,085	467,262	504,514
191	Rocky Mount	51,459	53,549	57,167	60,966	64,969	69,192	73,665	76,884	80,864
192	Tarboro	24,590	25,083	25,916	26,780	27,671	28,605	29,586	30,317	31,228
193	Raleigh	579,948	615,708	679,878	750,250	827,432	912,087	1,004,949	1,057,366	1,133,244
194	Mocksville	15,669	16,434	17,801	19,301	20,946	22,745	24,716	25,817	27,447
195	Lexington	72,150	74,960	80,014	85,585	91,728	98,519	106,036	110,145	116,171
196	Manteo	28,385	30,007	32,788	35,676	38,653	41,701	44,808	47,459	50,398
197	Asheboro	60,538	61,292	62,683	64,260	66,015	67,955	70,083	71,239	72,924
198	Siler City	37,029	39,636	44,414	49,780	55,808	62,562	70,127	73,727	79,656
199	Wilson	46,155	47,201	48,928	50,636	52,331	54,025	55,722	57,500	59,172
200	Salisbury	54,548	55,942	58,269	60,606	62,959	65,347	67,783	70,078	72,416
201	Smithfield	71,293	75,804	83,854	92,602	102,085	112,351	123,429	130,270	139,573
202	Lincolnton	25,769	26,776	28,544	30,449	32,506	34,725	37,121	38,635	40,658
203	Charlotte	708,403	757,342	845,801	943,506	1,051,225	1,169,797	1,300,110	1,370,405	1,476,672
204	Concord	90,984	95,794	104,377	113,706	123,826	134,775	146,613	153,677	163,711
205	Gastonia	93,408	95,525	99,351	103,608	108,345	113,637	119,537	122,482	127,162
206	Monroe	76,166	81,020	89,776	99,454	110,180	122,089	135,351	142,220	152,794
207	Hickory	95,027	97,094	100,498	103,850	107,154	110,425	113,666	116,977	120,355
208	Southern Pines	44,736	47,405	52,212	57,525	63,389	69,869	77,032	80,894	86,649
209	Raeford-Silver City	13,754	14,404	15,579	16,894	18,360	20,006	21,860	22,753	24,200
210	Sanford	33,134	34,287	36,298	38,421	40,670	43,074	45,648	47,470	49,673
211	Sussex	62,276	63,664	66,042	68,525	71,121	73,856	76,749	78,918	81,561
212	Paterson	229,683	232,264	236,786	241,615	246,789	252,346	258,327	262,484	267,539

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
213	Paramus	605,489	618,843	641,926	666,090	691,398	717,906	745,650	767,945	793,004
214	Phillipsburg	47,808	48,780	50,484	52,315	54,272	56,381	58,644	60,198	62,112
215	Parsippany Troy Hills	380,490	388,674	402,939	418,011	433,925	450,696	468,341	481,819	497,595
216	Newark	455,427	457,911	462,621	468,000	473,998	480,559	487,633	491,791	497,842
217	Jersey City-Hoboken	307,431	315,056	329,177	345,163	363,160	383,367	406,026	416,743	434,468
218	Flemington	77,174	79,557	83,819	88,504	93,664	99,377	105,703	109,152	114,306
219	Bridgewater-Somerville	224,877	233,590	249,457	267,208	287,125	309,520	334,777	347,194	366,817
220	Elizabeth	294,284	299,552	309,028	319,423	330,777	343,147	356,593	365,124	376,228
221	New Brunswick	500,535	511,675	531,265	552,216	574,602	598,488	623,954	642,325	664,312
222	Trenton	265,561	272,421	284,357	296,965	310,296	324,398	339,332	349,606	363,288
223	Willingboro	267,115	276,908	294,210	312,747	332,577	353,727	376,249	391,357	411,059
224	Camden	257,780	261,978	269,056	276,233	283,480	290,796	298,181	304,957	312,409
225	Woodbury	126,573	129,707	135,161	140,862	146,786	152,900	159,175	164,303	170,218
226	Penns Grove-Carneys Point	28,572	28,659	28,869	29,160	29,520	29,953	30,446	30,559	30,900
227	Lawrence	413,911	425,546	445,904	467,546	490,551	514,992	540,952	559,929	582,605
228	Cambridge - Burlington	1,097,473	1,137,380	1,206,816	1,280,060	1,357,285	1,438,656	1,524,336	1,589,070	1,665,527
229	Worcester	423,017	436,885	461,089	486,750	513,975	542,872	573,556	595,781	622,803
230	Boston	690,699	704,991	729,935	756,392	784,494	814,393	846,272	867,658	896,161
231	Quincy	433,786	452,887	486,728	523,257	562,713	605,349	651,441	680,988	719,981
232	Alexandria (Old Town)	52,531	51,420	56,227	58,635	61,929	64,102	63,170	67,583	70,130
233	Metro-Ballston Station	146,936	153,812	169,978	175,879	178,975	178,922	178,922	191,477	194,555
234	Downtown	144,406	145,724	147,174	147,994	148,172	148,172	151,012	151,270	152,002
235	Johns Hopkins Hospital	127,354	130,874	136,483	142,067	145,916	145,924	153,990	157,873	161,856
236	Brooklyn Manor	9,025	9,045	9,105	9,176	9,247	9,247	9,297	9,364	9,413
237	South Baltimore - Locust Point	7,775	7,743	7,724	7,713	7,705	7,705	7,641	7,643	7,628
238	Druid Hill Park - Mondawmin Mall	101,601	102,308	103,397	104,277	104,586	104,586	106,038	106,610	107,186
239	The National Mall	96,514	98,841	107,260	111,330	114,446	115,592	119,046	124,828	128,163

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
240	Capitol Hill - Union Station	137,170	145,364	176,077	176,880	183,002	184,782	190,145	205,932	211,418
241	Washington Hospital Center	55,780	56,978	57,422	67,061	70,245	70,939	73,048	78,140	81,779
242	Wesley Heights	61,208	61,670	62,590	62,590	63,810	64,446	66,356	66,517	67,415
243	Brightwood	21,203	21,203	21,338	21,338	22,891	23,120	23,804	24,092	24,738
244	Congress Heights	28,285	29,313	31,309	52,572	55,335	55,889	57,551	68,613	74,898
245	Capital View	12,069	14,416	14,815	14,815	20,774	20,979	21,598	24,064	25,734
246	Chevy Chase	2,889	2,889	2,889	2,889	2,889	2,918	2,996	2,966	2,987
247	Downtown DC	374,093	375,414	379,559	379,559	380,812	384,617	396,130	394,143	397,803
248	Logan Circle	47,241	47,658	48,408	48,408	51,879	52,399	53,954	54,894	56,342
249	Pentagon	72,365	79,427	84,821	86,237	87,715	94,207	96,640	101,214	103,890
250	Landmark - Van Dorn	66,220	68,235	79,561	90,545	99,621	107,888	112,041	124,034	133,090
251	Prince Frederick	35,130	38,552	41,742	43,433	44,276	45,120	45,963	48,987	49,930
252	Westminster	59,867	60,923	61,975	62,689	63,374	64,083	64,782	65,806	66,470
253	Eldersburg	23,334	23,758	24,169	24,444	24,756	25,035	25,310	25,725	25,996
254	Charlotte Hall (Peninsula) - Hughesville	4,986	5,609	5,918	6,259	6,587	6,915	7,243	7,682	7,963
255	Waldorf	46,750	49,665	52,040	54,134	56,079	58,022	59,966	62,629	64,453
256	Marbury-Pomonkey	10,581	10,714	11,214	11,671	12,099	12,526	12,954	13,394	13,849
257	Lexington Park	65,243	68,425	71,836	74,845	76,853	78,910	81,027	84,583	86,772
258	Bethesda	144,679	150,173	157,474	159,976	162,866	164,867	165,789	172,190	174,415
259	Silver Spring	55,512	56,368	56,978	59,007	61,220	61,686	61,911	63,964	65,210
260	Wheaton	68,964	73,457	74,368	75,394	77,374	78,596	79,172	81,668	82,496
261	Rockville	162,041	167,513	180,337	194,317	205,792	215,728	221,478	236,583	247,522
262	Potomac	46,922	49,510	51,967	52,824	53,568	53,957	54,747	56,825	57,434
263	Gaithersburg - Germantown	142,923	150,836	176,622	203,771	230,453	250,545	266,146	294,788	318,691
264	Olney	31,238	32,561	33,812	34,562	35,296	35,750	35,964	37,366	37,888
265	Damascus-Clarksburg	10,295	11,524	15,267	19,715	25,767	29,455	30,883	36,359	40,635
266	Dawsonville	3,881	3,892	3,896	3,899	3,906	3,913	3,915	3,923	3,927
267	Hyattsville (Chillum)	24,619	24,957	25,551	26,285	27,214	28,337	30,320	30,535	31,646

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
268	College Park	46,396	47,878	51,179	53,417	56,446	60,039	63,194	65,861	68,945
269	Hyattsville (Edmonston)	17,290	17,494	17,953	18,562	19,457	20,349	20,512	21,296	21,991
270	Lanham (Landover Hills)	25,612	25,868	27,666	29,788	32,035	34,905	37,848	39,292	41,880
271	Fairmount Heights	12,460	12,393	12,582	12,893	13,360	14,060	15,340	15,201	15,848
272	Glenarden	11,207	11,338	11,584	11,959	12,519	13,375	14,767	14,724	15,458
273	District Heights	25,002	25,198	25,684	26,904	27,646	28,477	29,038	29,897	30,746
274	Marlow Heights	33,547	33,844	34,448	35,390	36,639	38,832	42,685	42,368	44,242
275	Upper Marlboro	23,441	24,950	29,137	33,551	39,497	44,032	48,866	53,206	58,278
276	Beltsville	76,810	79,161	85,834	95,794	108,972	122,416	132,656	141,263	153,239
277	NASA Goddard Space Flight Center	25,434	24,957	24,695	25,472	26,518	27,699	27,928	28,325	29,199
278	Bowie	21,306	22,174	23,518	25,620	27,624	29,679	29,908	32,303	34,008
279	Woodmore	19,880	20,563	21,335	22,275	23,147	24,900	29,133	28,699	30,383
280	Cheltenham	29,688	31,110	32,456	33,180	34,214	35,477	37,341	38,252	39,361
281	Fort Washington	38,787	40,728	42,004	44,024	45,410	47,635	51,710	52,566	54,659
282	Severn	9,412	9,781	10,247	10,702	11,317	11,996	11,996	12,725	13,198
283	Odenton	12,693	14,217	16,582	19,447	22,286	25,057	25,057	28,805	31,111
284	Crofton	8,329	8,384	8,437	8,482	8,590	8,693	8,693	8,790	8,859
285	Crownsville	29,399	30,154	30,690	31,076	31,687	32,255	32,255	33,080	33,469
286	Davidsonville	7,395	7,440	7,480	7,520	7,675	7,802	7,802	7,904	7,992
287	Galesville	14,924	15,204	15,551	15,950	16,330	16,728	16,728	17,271	17,586
288	Riviera Beach	15,875	16,155	17,633	19,141	19,747	20,669	20,669	22,302	23,194
289	Annapolis - Cape St. Clair	64,594	65,925	66,177	66,394	67,848	69,015	69,015	70,083	70,746
290	Pasadena (Millersville)	23,384	23,706	23,928	24,220	24,788	25,293	25,293	25,808	26,164
291	Linthicum Heights	27,621	28,506	29,250	32,334	33,416	35,277	35,277	37,653	39,164
292	Glenmore	32,102	32,656	33,276	34,112	35,294	36,439	36,439	37,656	38,503
293	Baltimore Washington International Airport	6,371	6,778	7,494	7,951	8,255	8,617	8,617	9,355	9,673
294	Fort Meade-Patuxent Research Refuge	69,237	78,462	94,269	102,663	111,707	115,104	115,104	131,289	137,313

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
295	Hanover	48,456	51,722	59,315	64,225	66,321	69,375	69,375	76,567	79,529
296	Edgewood	29,006	30,354	32,154	34,747	35,826	36,047	41,053	41,697	43,572
297	Bel Air	42,850	43,889	46,854	48,378	50,132	50,377	55,080	56,005	57,931
298	Aberdeen	48,115	52,623	55,821	57,941	59,816	60,688	68,200	69,333	71,722
299	Catonsville - Halethorpe	89,044	90,537	92,549	93,955	95,007	95,954	99,863	100,559	102,160
300	Randallstown	60,945	61,434	62,703	63,638	64,269	64,796	68,160	68,124	69,324
301	Reisterstown	50,981	53,265	58,281	59,246	59,822	60,307	67,902	68,250	70,333
302	Brooklandville	21,721	21,948	22,358	22,655	22,890	23,073	23,748	23,930	24,249
303	Towson	161,495	163,461	166,515	168,675	170,400	171,833	176,702	178,164	180,485
304	Hereford	13,992	14,125	14,421	14,649	14,795	14,907	15,500	15,578	15,821
305	Perry Hall	18,530	18,760	19,151	19,429	19,648	19,813	20,447	20,624	20,920
306	Rosedale-Rossville	98,908	103,370	105,800	107,404	108,590	109,498	116,785	117,207	119,175
307	Frederick	117,802	121,920	127,109	131,236	134,248	137,333	140,485	145,511	148,781
308	Thurmont	14,601	15,468	16,468	17,045	17,473	17,910	18,359	19,258	19,714
309	Sterling	107,831	118,139	134,371	146,859	155,723	163,412	170,189	186,046	195,236
310	Ashburn South	50,854	57,809	74,764	87,079	94,917	101,226	106,480	121,930	130,592
311	Leesburg	26,512	29,784	37,814	43,349	47,760	50,961	53,270	60,751	65,016
312	Purcellville	7,622	8,572	10,460	12,137	13,032	13,823	14,574	16,423	17,498
313	Herndon - Reston	177,747	185,838	197,769	209,009	218,697	229,644	232,122	247,071	256,170
314	Centreville	112,408	117,405	126,428	136,159	144,048	147,081	150,115	161,214	167,454
315	Fairfax	76,896	79,164	82,732	86,064	88,677	90,720	92,879	96,586	99,149
316	Vienna	113,627	117,175	121,382	125,744	128,805	132,078	135,231	139,807	143,164
317	Seven Corners	75,684	78,436	81,886	84,686	86,396	87,215	85,986	90,572	91,759
318	Springfield	69,656	77,000	79,426	81,417	82,650	84,644	86,596	90,174	91,286
319	Huntington	110,585	117,265	122,939	127,783	131,740	136,065	140,389	146,501	150,510
320	McLean	127,743	133,266	144,841	154,200	160,380	167,978	175,308	185,352	193,185
321	Great Falls	3,893	3,974	4,155	4,341	4,389	4,389	4,389	4,590	4,656
322	Warrenton	38,684	41,322	48,448	53,350	58,750	64,694	71,246	76,564	82,434

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
323	Dale City	88,232	93,216	102,298	111,580	120,660	127,397	137,178	145,863	154,530
324	Manassas	66,827	70,030	75,377	80,820	86,217	90,643	96,241	101,513	106,692
325	Haymarket	42,952	52,291	65,760	79,528	93,257	103,184	117,756	131,208	143,912
326	Stafford	49,636	53,616	60,114	66,603	71,655	76,703	82,111	88,555	94,038
327	200-KGC01-King George	17,614	20,229	23,327	26,425	29,062	31,693	34,567	37,792	40,504
328	Columbia	83,387	85,808	90,758	94,837	99,096	101,231	103,384	108,610	111,968
329	Ellicott City	32,176	32,405	34,382	36,287	37,336	37,336	37,336	39,465	40,383
330	Elkridge	23,474	26,337	30,436	34,003	37,393	39,196	41,015	45,598	48,302
331	Peninsula Laurel-Savage	32,993	36,361	39,509	43,474	46,091	46,173	46,257	51,137	52,789
332	Clarksville	15,633	17,070	17,548	18,184	18,400	18,400	18,400	19,347	19,443
333	Cooksville	9,774	10,502	11,680	13,238	14,212	14,359	14,508	16,182	16,928

1.3 Study Area Per Capita Income Data and Forecasts (2012 US$)

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
1	Norfolk (Downtown)	24,668	25,349	26,474	27,599	28,723	29,848	30,973	32,099	33,225
2	Lamberts Point - Colonial Place	25,265	25,963	27,115	28,267	29,419	30,571	31,723	32,877	34,030
3	Fairmount Park - Lafayette Annex	23,617	24,269	25,346	26,423	27,499	28,576	29,653	30,732	31,809
4	Glenwood Park	17,495	17,978	18,776	19,573	20,371	21,169	21,967	22,765	23,564
5	Norfolk International Airport	24,494	25,170	26,287	27,404	28,521	29,638	30,755	31,873	32,991
6	Virginia Beach	44,116	45,649	48,174	50,700	53,226	55,752	58,278	60,808	63,337
7	Chinese Corner	31,169	32,252	34,036	35,821	37,606	39,390	41,175	42,962	44,749
8	Oceana Naval Air Station	26,558	27,480	29,001	30,522	32,042	33,563	35,083	36,606	38,129
9	Berkley - Campostella	15,109	15,526	16,215	16,904	17,593	18,282	18,971	19,661	20,351
10	Portsmouth	22,131	22,839	24,006	25,174	26,341	27,508	28,676	29,844	31,013
11	Victory Park	21,794	22,490	23,640	24,790	25,939	27,089	28,238	29,389	30,540
12	Arostead Forest - Craney Island	26,835	27,693	29,109	30,524	31,940	33,355	34,771	36,188	37,605
13	Bowers Hill	29,032	30,107	31,876	33,645	35,414	37,183	38,952	40,723	42,494
14	Boone	32,223	33,415	35,378	37,341	39,305	41,268	43,232	45,198	47,164
15	Loxley Gardens - Geneva Park	24,172	25,067	26,540	28,012	29,485	30,958	32,431	33,906	35,381
16	South Norfolk	18,878	19,577	20,727	21,877	23,027	24,178	25,328	26,480	27,632
17	1200 Battlefield Blvd N	28,237	29,282	31,002	32,723	34,443	36,164	37,884	39,608	41,330
18	910 Great Bridge Blvd	31,244	32,400	34,304	36,208	38,112	40,015	41,919	43,826	45,732
19	Chesapeake	37,718	39,114	41,412	43,710	46,009	48,307	50,605	52,907	55,208

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
20	Bennett Corner	35,261	36,447	38,401	40,356	42,311	44,265	46,220	48,177	50,134
21	Suffolk	20,579	21,271	22,412	23,552	24,693	25,834	26,975	28,117	29,259
22	Holland	28,199	29,147	30,710	32,273	33,836	35,400	36,963	38,528	40,093
23	Kings Fork	29,792	30,794	32,445	34,097	35,748	37,400	39,051	40,705	42,359
24	Smithfield	34,341	35,624	37,737	39,851	41,964	44,077	46,190	48,307	50,423
25	Zuni	27,128	28,141	29,811	31,480	33,150	34,819	36,488	38,160	39,832
26	Newport News (Downtown South)	12,667	12,959	13,443	13,926	14,410	14,893	15,376	15,860	16,344
27	Newport News Amtrak Station	20,390	20,860	21,638	22,416	23,195	23,973	24,751	25,530	26,309
28	Newport News (Downtown Peninsula)	23,745	24,293	25,199	26,105	27,011	27,917	28,823	29,730	30,637
29	Newport News (Reed)	15,058	15,405	15,980	16,555	17,129	17,704	18,278	18,854	19,429
30	Glendale - Beaconsville	33,002	33,763	35,023	36,282	37,541	38,801	40,060	41,321	42,581
31	Charles	31,066	31,782	32,968	34,154	35,339	36,525	37,710	38,897	40,083
32	Sunsan Constant Dr	23,319	23,857	24,747	25,637	26,527	27,417	28,307	29,198	30,089
33	2 Shore Park Dr	16,437	16,817	17,444	18,071	18,698	19,326	19,953	20,581	21,209
34	Hampton (West)	20,712	21,413	22,570	23,726	24,883	26,039	27,196	28,354	29,512
35	Hampton (Downtown)	28,846	29,823	31,434	33,045	34,655	36,266	37,877	39,490	41,102
36	Fox Corner	28,535	29,501	31,095	32,688	34,281	35,874	37,468	39,063	40,658
37	Chapel Village	27,037	27,953	29,462	30,972	32,481	33,991	35,501	37,012	38,524
38	Poquoson	39,447	41,009	43,579	46,149	48,719	51,288	53,858	56,433	59,006
39	Yorktown (Rt. 134 & Rt. 600)	35,058	36,446	38,730	41,014	43,298	45,582	47,866	50,154	52,441

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
40	Yorktown (West)	33,113	34,424	36,581	38,739	40,896	43,053	45,210	47,371	49,531
41	Greensprings-Plantation Heights	41,375	43,014	45,709	48,405	51,100	53,796	56,491	59,192	61,891
42	Skimino	41,375	43,014	45,709	48,405	51,100	53,796	56,491	59,192	61,891
43	Charleston Heights - York Terrace	34,682	36,056	38,315	40,575	42,834	45,094	47,353	49,616	51,879
44	Williamsburg	15,518	16,247	17,443	18,639	19,835	21,031	22,227	23,425	24,623
45	Williamsburg (Southeast - Forest Hill Park)	30,745	32,188	34,558	36,927	39,297	41,666	44,036	46,410	48,783
46	James Terrace - Grove	52,099	54,544	58,560	62,575	66,590	70,605	74,620	78,643	82,665
47	Jamestown - Hollybrook	41,119	42,676	45,239	47,803	50,366	52,929	55,493	58,060	60,627
48	Canterbury Hills - Jamestown Farms	40,219	41,742	44,249	46,757	49,264	51,771	54,278	56,789	59,300
49	Toano	33,906	35,190	37,304	39,417	41,531	43,645	45,758	47,875	49,992
50	Gloucester	28,788	29,687	31,169	32,651	34,133	35,615	37,097	38,581	40,064
51	Grassfield - Chesapeake Regional Apt.	30,089	31,202	33,036	34,869	36,702	38,536	40,369	42,205	44,041
52	Gent-Park Place	39,675	40,771	42,580	44,389	46,198	48,007	49,817	51,628	53,439
53	Huntersville (Hunter's Village)	12,063	12,396	12,946	13,496	14,046	14,596	15,146	15,697	16,248
54	Ocean View - Willoughby Beach	25,619	26,326	27,494	28,662	29,830	30,999	32,167	33,336	34,506
55	Sussex - Wards Corner	37,206	38,233	39,930	41,627	43,323	45,020	46,716	48,415	50,113
56	Thomas Corner	22,345	22,962	23,981	25,000	26,019	27,038	28,057	29,077	30,097
57	London Bridge	38,212	39,539	41,727	43,915	46,103	48,291	50,479	52,670	54,861
58	Nimmo-Woodhouse Corner	33,801	34,976	36,911	38,846	40,782	42,717	44,653	46,591	48,529
59	Westhaven Park	25,275	26,083	27,417	28,750	30,083	31,416	32,749	34,084	35,419

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
60	Hawthorne Drive, Chesapeake	29,028	30,102	31,871	33,639	35,408	37,177	38,945	40,717	42,488
61	Shenandoah Pkwy	36,371	37,717	39,933	42,149	44,366	46,582	48,798	51,018	53,236
62	St. Brides	32,075	33,261	35,216	37,170	39,124	41,079	43,033	44,991	46,947
63	Deer Park - Harpersville	26,152	26,756	27,754	28,752	29,750	30,748	31,746	32,745	33,744
64	Newport News/Williamsburg International Airport	27,896	28,540	29,604	30,669	31,734	32,798	33,863	34,928	35,994
65	Hampton (East)	26,183	27,070	28,531	29,993	31,455	32,917	34,379	35,843	37,307
66	504 E Mercury Blvd	20,272	20,958	22,090	23,222	24,354	25,486	26,618	27,751	28,884
67	Greenwood Farms	23,326	24,117	25,419	26,721	28,024	29,326	30,629	31,933	33,237
68	Drummonds Corner	30,276	31,302	32,992	34,683	36,373	38,064	39,754	41,447	43,139
69	Yorktown - Grafton	43,601	45,327	48,167	51,008	53,848	56,689	59,529	62,375	65,219
70	Pecan Gardens	26,393	27,310	28,821	30,332	31,844	33,355	34,866	36,379	37,892
71	Acredale	30,411	31,468	33,209	34,951	36,692	38,433	40,174	41,918	43,662
72	Woodhaven Shores - New Kent Co. Airport	30,480	31,515	33,220	34,925	36,631	38,336	40,041	41,749	43,456
73	Charles City	25,913	27,055	28,933	30,810	32,688	34,565	36,443	38,324	40,204
74	Swift Creek Resevoir	36,854	38,001	39,893	41,784	43,676	45,568	47,460	49,355	51,248
75	Chesterfield County Airport	25,209	25,993	27,287	28,581	29,875	31,169	32,463	33,759	35,055
76	East Highland Park	23,345	24,179	25,553	26,927	28,301	29,675	31,049	32,425	33,801
77	Church Hill	15,893	16,409	17,260	18,111	18,962	19,813	20,664	21,516	22,367
78	Ginter Park - Hotchkiss Field	23,587	24,353	25,615	26,878	28,141	29,403	30,666	31,931	33,195
79	Richmond (Downtown-West)	21,010	21,692	22,817	23,942	25,067	26,191	27,316	28,442	29,568

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
80	Richmond (The Fan District)	30,058	31,034	32,643	34,252	35,861	37,470	39,080	40,691	42,302
81	Richmond (West End)	60,255	62,211	65,436	68,662	71,888	75,114	78,340	81,570	84,799
82	Ashland	32,015	33,226	35,221	37,215	39,209	41,204	43,198	45,195	47,192
83	Goodallr-Farrington	38,926	40,399	42,824	45,249	47,674	50,098	52,523	54,952	57,380
84	Tuckahoe	42,596	44,117	46,624	49,131	51,638	54,145	56,652	59,163	61,673
85	Chester	28,185	29,062	30,509	31,956	33,402	34,849	36,296	37,745	39,193
86	Richmond (Southside)	24,165	24,949	26,243	27,536	28,830	30,124	31,417	32,713	34,008
87	Laurel	35,420	36,686	38,770	40,855	42,940	45,024	47,109	49,197	51,284
88	Powhatan (Rt. 60 & Dorset Rd.)	37,589	39,271	42,034	44,797	47,560	50,324	53,087	55,855	58,622
89	Sabot	70,484	74,398	80,804	87,211	93,618	100,025	106,432	112,854	119,273
90	Richmond International Apt. (Sandston)	25,989	26,918	28,447	29,977	31,506	33,036	34,566	36,098	37,629
91	Mechanicsville (Henry Clay Heights)	35,851	37,208	39,441	41,674	43,908	46,141	48,374	50,611	52,847
92	Sandston (Rt. 156 & Rt. 33)	28,664	29,688	31,375	33,062	34,749	36,436	38,123	39,813	41,502
93	Richmond (Downtown-East)	45,425	46,899	49,331	51,763	54,195	56,627	59,058	61,494	63,928
94	Meadowville - Cameron Hills	45,918	47,347	49,704	52,061	54,419	56,776	59,133	61,493	63,853
95	Robious & Hylton Park	40,606	41,869	43,954	46,038	48,123	50,207	52,292	54,379	56,465
96	Ethridge Estates	25,901	26,881	28,496	30,111	31,725	33,340	34,955	36,572	38,188
97	Fort Lee	20,282	21,050	22,315	23,579	24,843	26,108	27,372	28,638	29,904
98	Rt. 106 & Rt. 156	39,364	40,855	43,309	45,763	48,216	50,670	53,124	55,582	58,039
99	Petersburg (Dinwiddie County Airport - PTB)	21,745	22,592	23,984	25,377	26,770	28,162	29,555	30,950	32,345

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
100	Petersburg (Blandford)	11,639	12,092	12,838	13,583	14,329	15,074	15,820	16,566	17,313
101	Berkley Manor	20,664	21,468	22,792	24,115	25,439	26,762	28,086	29,411	30,737
102	Petersburg (Downtown)	14,817	15,394	16,343	17,292	18,241	19,190	20,139	21,090	22,040
103	Petersburg (Kennelworth)	19,038	19,779	20,998	22,218	23,437	24,656	25,876	27,097	28,318
104	Camelot	26,957	28,006	29,732	31,459	33,185	34,912	36,638	38,368	40,096
105	Petersburg (South)	24,612	25,570	27,146	28,722	30,299	31,875	33,451	35,030	36,609
106	Colonial Heights	25,958	26,968	28,631	30,293	31,956	33,618	35,281	36,946	38,611
107	Colonial Heights (East)	34,610	35,957	38,173	40,390	42,607	44,823	47,040	49,260	51,480
108	Ettrick (Amtrak Petersburg)	19,766	20,381	21,396	22,411	23,425	24,440	25,455	26,471	27,487
109	Hopewell	19,777	20,525	21,758	22,991	24,224	25,457	26,690	27,924	29,159
110	Matoaca	28,192	29,070	30,517	31,964	33,411	34,859	36,306	37,755	39,204
111	Screamersville	31,969	32,963	34,604	36,245	37,887	39,528	41,169	42,812	44,455
112	Pickadat Corner	33,416	34,455	36,171	37,886	39,601	41,317	43,032	44,750	46,467
113	Lake Chesdin Pkwy & Ivey Mill Rd.	34,425	35,496	37,263	39,030	40,798	42,565	44,332	46,101	47,870
118	Dinwiddie	36,335	37,749	40,076	42,403	44,731	47,058	49,385	51,716	54,046
119	Templeton	26,640	27,648	29,309	30,970	32,630	34,291	35,952	37,615	39,278
114	New Kent	29,061	30,047	31,673	33,299	34,925	36,550	38,176	39,804	41,432
115	Sherwood Forest - Rustic	33,112	34,572	36,971	39,370	41,769	44,168	46,567	48,971	51,373
116	Powhatan (Rt. 522 & Three Bridges Rd.)	25,696	26,846	28,735	30,624	32,513	34,402	36,290	38,183	40,075
117	Goochland	31,917	33,689	36,591	39,492	42,393	45,294	48,196	51,104	54,010

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
120	Dutton	30,942	31,907	33,500	35,093	36,686	38,279	39,871	41,467	43,061
121	Elkton	30,033	31,148	32,984	34,821	36,657	38,493	40,329	42,168	44,007
122	Bristol	37,887	39,569	42,333	45,096	47,860	50,623	53,387	56,156	58,924
123	Warwick	33,489	34,767	36,870	38,974	41,077	43,180	45,283	47,390	49,496
124	Providence	26,663	27,499	28,878	30,257	31,636	33,015	34,393	35,774	37,154
125	Newport	39,406	41,160	44,041	46,923	49,804	52,686	55,567	58,454	61,340
126	Wakefield-Westerly	37,385	39,052	41,789	44,527	47,264	50,001	52,739	55,482	58,223
127	Levittown	37,906	39,483	42,075	44,668	47,260	49,853	52,445	55,043	57,639
128	Norristown	42,552	44,206	46,926	49,647	52,368	55,088	57,809	60,534	63,259
129	Philadelphia	22,464	23,029	23,962	24,895	25,828	26,761	27,694	28,628	29,562
130	Springfield-Media	33,827	35,097	37,189	39,280	41,372	43,464	45,555	47,650	49,745
131	Downingtown-Exton	43,527	45,460	48,636	51,812	54,989	58,165	61,341	64,523	67,704
132	Hartford-Glastonbury	35,143	36,417	38,517	40,616	42,715	44,814	46,913	49,016	51,118
133	Norwich-New London	34,528	35,903	38,165	40,427	42,689	44,951	47,213	49,478	51,743
134	New Haven	33,439	34,621	36,569	38,516	40,463	42,411	44,358	46,309	48,258
135	Middletown	40,760	42,380	45,044	47,709	50,374	53,039	55,703	58,373	61,041
136	Bridgeport	50,005	52,406	56,346	60,286	64,227	68,167	72,107	76,055	80,002
137	Culpeper	28,022	29,012	30,643	32,273	33,904	35,534	37,165	38,798	40,430
138	Fredericksburg	31,820	32,873	34,611	36,348	38,085	39,823	41,560	43,300	45,039
139	Hague	27,865	28,990	30,842	32,693	34,544	36,395	38,247	40,101	41,955

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
140	Bowling Green	26,903	27,917	29,585	31,254	32,922	34,591	36,260	37,931	39,602
141	Tappahannock	23,214	24,110	25,586	27,062	28,538	30,014	31,490	32,968	34,446
142	Warsaw	21,567	22,024	22,780	23,536	24,292	25,048	25,804	26,561	27,318
143	Heathsville	29,390	30,621	32,645	34,669	36,693	38,717	40,741	42,769	44,796
144	Mattaponi	25,769	26,738	28,334	29,929	31,525	33,120	34,716	36,314	37,911
145	King William	28,697	29,698	31,348	32,999	34,649	36,299	37,949	39,602	41,254
146	Irvington	30,907	32,420	34,902	37,384	39,865	42,347	44,829	47,317	49,802
147	Topping-Deltaville	31,763	33,088	35,266	37,445	39,623	41,801	43,980	46,162	48,343
148	Foster	30,534	32,078	34,609	37,141	39,672	42,204	44,735	47,272	49,808
149	Surry	24,821	25,867	27,586	29,305	31,024	32,743	34,462	36,184	37,905
150	Lunenburg	17,706	18,228	19,090	19,952	20,814	21,676	22,537	23,401	24,263
151	Waverly	17,739	18,315	19,263	20,212	21,160	22,108	23,057	24,007	24,956
152	Lawrenceville	17,754	18,258	19,089	19,921	20,752	21,583	22,415	23,247	24,079
153	Franklin	21,204	22,086	23,535	24,984	26,433	27,883	29,332	30,784	32,235
154	Emporia	17,575	18,001	18,704	19,407	20,110	20,813	21,516	22,220	22,923
155	South Mill	20,578	21,312	22,521	23,731	24,940	26,150	27,359	28,571	29,782
156	Wilmington	33,057	34,100	35,821	37,542	39,264	40,985	42,706	44,429	46,152
157	Plymouth-Kingston	34,979	36,543	39,112	41,681	44,251	46,820	49,389	51,963	54,536
158	Taunton	29,427	30,512	32,300	34,088	35,876	37,664	39,452	41,242	43,032
159	Hempstead	43,810	45,454	48,160	50,867	53,573	56,279	58,986	61,696	64,406

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
160	Brooklyn	24,970	25,622	26,699	27,777	28,854	29,931	31,009	32,088	33,166
161	Yonkers-New Rochelle	48,856	50,898	54,254	57,610	60,966	64,323	67,679	71,041	74,402
162	Bronx	18,375	18,724	19,302	19,880	20,458	21,036	21,614	22,192	22,770
163	New York City	64,802	68,054	73,388	78,721	84,054	89,387	94,720	100,065	105,407
164	Staten Island	32,230	33,315	35,103	36,891	38,678	40,466	42,254	44,044	45,834
165	Queens	26,861	27,267	27,941	28,614	29,288	29,962	30,635	31,309	31,983
166	Carmel	41,066	42,737	45,487	48,237	50,986	53,736	56,486	59,240	61,994
167	Spring Valley	35,983	37,377	39,672	41,967	44,262	46,557	48,852	51,151	53,449
168	Dunn	20,483	21,341	22,750	24,159	25,569	26,978	28,388	29,799	31,211
169	Fayetteville	23,712	24,663	26,228	27,792	29,357	30,921	32,485	34,052	35,619
170	Greenville	23,556	24,459	25,946	27,434	28,921	30,408	31,895	33,385	34,874
171	Gatesville	21,700	22,376	23,490	24,604	25,719	26,833	27,947	29,063	30,178
172	Camden	26,956	28,087	29,947	31,807	33,668	35,528	37,388	39,252	41,115
173	Currituck	27,078	28,206	30,060	31,914	33,768	35,622	37,477	39,334	41,191
174	King	21,732	22,473	23,694	24,916	26,137	27,358	28,579	29,802	31,025
175	Jackson	18,440	19,282	20,665	22,048	23,431	24,814	26,197	27,583	28,968
176	Ahoskie	17,914	18,529	19,542	20,555	21,569	22,582	23,595	24,610	25,624
177	Warrenton	19,663	20,383	21,569	22,756	23,942	25,128	26,315	27,503	28,691
178	Henderson	18,011	18,608	19,592	20,576	21,559	22,543	23,527	24,512	25,497
179	Oxford	22,506	23,341	24,717	26,092	27,468	28,844	30,219	31,597	32,974

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
180	Rosemary	18,634	19,346	20,518	21,689	22,861	24,032	25,204	26,377	27,550
181	Elizabeth City	24,237	24,986	26,221	27,456	28,692	29,927	31,162	32,399	33,636
182	Hertford	22,261	23,191	24,721	26,251	27,780	29,310	30,840	32,372	33,904
183	Edenton	20,585	21,475	22,938	24,400	25,863	27,326	28,788	30,254	31,718
184	Yadkinville	22,266	23,026	24,277	25,529	26,781	28,032	29,284	30,537	31,790
185	Franklinton	22,796	23,769	25,369	26,968	28,568	30,168	31,768	33,370	34,972
186	Winston-Salem	27,143	27,988	29,384	30,779	32,174	33,570	34,965	36,362	37,759
187	Greensboro	27,440	28,363	29,885	31,407	32,929	34,451	35,973	37,497	39,021
188	Burlington	24,175	24,920	26,148	27,377	28,606	29,835	31,063	32,294	33,524
189	Chapel Hill	35,340	36,953	39,602	42,252	44,901	47,551	50,200	52,855	55,508
190	Durham	28,678	29,736	31,478	33,219	34,961	36,702	38,444	40,188	41,932
191	Rocky Mount	24,452	25,332	26,782	28,232	29,682	31,132	32,581	34,034	35,485
192	Tarboro	18,579	19,211	20,253	21,295	22,336	23,378	24,420	25,463	26,506
193	Raleigh	34,227	35,575	37,793	40,011	42,228	44,446	46,664	48,885	51,106
194	Mocksville	27,397	28,503	30,322	32,140	33,959	35,778	37,597	39,418	41,240
195	Lexington	23,484	24,323	25,705	27,087	28,468	29,850	31,232	32,615	33,999
196	Manteo	32,550	34,010	36,408	38,805	41,203	43,601	45,999	48,401	50,802
197	Asheboro	22,039	22,676	23,726	24,777	25,828	26,879	27,929	28,982	30,033
198	Siler City	33,116	34,730	37,379	40,027	42,676	45,324	47,973	50,627	53,279
199	Wilson	21,580	22,344	23,603	24,862	26,121	27,380	28,639	29,900	31,160

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
200	Salisbury	22,434	23,155	24,344	25,533	26,722	27,912	29,101	30,292	31,482
201	Smithfield	23,561	24,517	26,089	27,660	29,232	30,803	32,375	33,949	35,523
202	Lincolnton	26,507	27,448	28,999	30,550	32,101	33,652	35,203	36,756	38,309
203	Charlotte	33,806	35,203	37,500	39,797	42,094	44,391	46,688	48,989	51,289
204	Concord	26,952	28,044	29,839	31,634	33,430	35,225	37,020	38,819	40,617
205	Gastonia	23,623	24,534	26,034	27,534	29,033	30,533	32,033	33,535	35,036
206	Monroe	29,811	30,965	32,865	34,765	36,664	38,564	40,464	42,367	44,269
207	Hickory	24,328	25,090	26,347	27,603	28,860	30,117	31,374	32,632	33,890
208	Southern Pines	28,073	29,348	31,441	33,533	35,626	37,719	39,812	41,909	44,005
209	Raeford-Silver City	19,927	20,729	22,047	23,366	24,684	26,003	27,321	28,642	29,962
210	Sanford	22,403	23,181	24,464	25,747	27,029	28,312	29,594	30,879	32,163
211	Sussex	38,302	39,881	42,477	45,073	47,670	50,266	52,862	55,463	58,063
212	Paterson	27,275	28,073	29,392	30,711	32,029	33,348	34,666	35,987	37,307
213	Paramus	44,520	46,377	49,431	52,484	55,537	58,591	61,644	64,703	67,761
214	Phillipsburg	34,742	35,968	37,988	40,008	42,028	44,047	46,067	48,090	50,112
215	Parsippany Troy Hills	49,914	52,322	56,273	60,225	64,176	68,127	72,078	76,037	79,995
216	Newark	33,247	34,534	36,652	38,770	40,888	43,006	45,124	47,245	49,366
217	Jersey City-Hoboken	33,678	34,884	36,872	38,859	40,846	42,834	44,821	46,811	48,801
218	Flemington	51,435	53,982	58,161	62,340	66,518	70,697	74,875	79,062	83,248
219	Bridgewater-Somerville	49,890	52,233	56,077	59,922	63,767	67,612	71,456	75,309	79,160

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
220	Elizabeth	35,904	37,080	39,018	40,957	42,895	44,834	46,772	48,714	50,654
221	New Brunswick	35,297	36,508	38,505	40,501	42,497	44,494	46,490	48,489	50,488
222	Trenton	37,956	39,441	41,885	44,329	46,773	49,217	51,661	54,109	56,556
223	Willingboro	37,389	38,880	41,333	43,785	46,238	48,691	51,144	53,601	56,057
224	Camden	31,154	32,200	33,925	35,650	37,375	39,100	40,825	42,552	44,279
225	Woodbury	33,190	34,303	36,138	37,973	39,808	41,643	43,478	45,316	47,153
226	Penns Grove-Carneys Point	28,858	29,716	31,132	32,548	33,963	35,379	36,795	38,213	39,630
227	Lawrence	35,361	36,828	39,240	41,652	44,064	46,477	48,889	51,305	53,721
228	Cambridge - Burlington	42,900	44,845	48,039	51,232	54,426	57,620	60,814	64,014	67,212
229	Worcester	32,489	33,714	35,730	37,746	39,763	41,779	43,795	45,815	47,833
230	Boston	33,059	34,473	36,796	39,119	41,443	43,766	46,089	48,417	50,744
231	Quincy	45,502	47,543	50,896	54,249	57,602	60,955	64,308	67,667	71,025
232	Alexandria (Old Town)	68,472	71,344	76,066	80,788	85,510	90,232	94,954	99,684	104,412
233	Metro-Ballston Station	63,412	65,844	69,849	73,853	77,857	81,862	85,866	89,877	93,887
234	Downtown	32,074	32,969	34,447	35,925	37,404	38,882	40,360	41,840	43,319
235	Johns Hopkins Hospital	26,497	27,236	28,457	29,678	30,900	32,121	33,342	34,564	35,787
236	Brooklyn Manor	16,502	16,962	17,722	18,483	19,243	20,004	20,764	21,526	22,287
237	South Baltimore - Locust Point	51,970	53,421	55,816	58,211	60,606	63,001	65,396	67,794	70,191
238	Druid Hill Park - Mondawmin Mall	21,660	22,265	23,263	24,261	25,260	26,258	27,256	28,256	29,255
239	The National Mall	51,403	53,653	57,352	61,051	64,749	68,448	72,146	75,852	79,556

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
240	Capitol Hill - Union Station	46,343	48,372	51,706	55,041	58,375	61,710	65,044	68,385	71,724
241	Washington Hospital Center	31,058	32,418	34,652	36,887	39,122	41,357	43,591	45,830	48,068
242	Wesley Heights	75,926	79,251	84,714	90,177	95,640	101,103	106,567	112,040	117,511
243	Brightwood	31,731	33,121	35,404	37,687	39,970	42,254	44,537	46,824	49,111
244	Congress Heights	19,210	20,051	21,433	22,815	24,197	25,579	26,962	28,346	29,731
245	Capital View	22,013	22,977	24,561	26,145	27,729	29,313	30,897	32,484	34,070
246	Chevy Chase	74,136	77,382	82,716	88,050	93,385	98,719	104,053	109,398	114,739
247	Downtown DC	69,413	72,452	77,446	82,441	87,435	92,430	97,424	102,428	107,430
248	Logan Circle	55,177	57,593	61,563	65,533	69,504	73,474	77,444	81,422	85,397
249	Pentagon	59,610	61,897	65,661	69,426	73,190	76,954	80,719	84,489	88,258
250	Landmark - Van Dorn	48,746	50,791	54,152	57,514	60,875	64,237	67,599	70,966	74,332
251	Prince Frederick	38,636	39,984	41,980	44,531	46,805	49,068	51,313	53,568	55,846
252	Westminster	33,772	34,982	37,006	39,209	41,229	42,629	44,442	46,665	48,588
253	Eldersburg	40,959	42,566	45,251	48,113	50,684	52,470	54,738	57,703	60,187
254	Charlotte Hall (Peninsula) - Hughesville	40,698	42,413	45,773	49,188	52,131	55,135	58,198	61,448	64,599
255	Waldorf	37,211	38,545	40,552	42,448	44,519	46,552	48,548	50,599	52,612
256	Marbury-Pomonkey	36,967	38,877	42,222	46,038	49,514	53,132	56,898	60,194	63,768
257	Lexington Park	36,082	37,457	39,879	42,093	44,535	46,911	49,242	51,572	53,927
258	Bethesda	84,705	88,165	95,010	101,631	109,504	118,580	126,974	132,726	140,293
259	Silver Spring	39,486	40,687	43,369	45,548	48,096	50,368	52,349	54,884	57,228

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
260	Wheaton	37,706	38,096	39,275	40,236	41,277	42,165	42,891	43,980	44,943
261	Rockville	47,158	48,644	51,950	54,969	58,299	61,916	64,805	67,869	71,082
262	Potomac	83,392	86,474	91,789	96,029	100,618	105,833	110,514	115,418	120,227
263	Gaithersburg - Germantown	37,380	38,631	40,606	42,378	44,396	46,397	47,821	50,011	51,900
264	Olney	45,000	46,615	49,018	51,077	53,123	55,585	57,378	59,926	62,129
265	Damascus-Clarksburg	47,483	49,793	53,934	58,022	62,620	67,426	71,995	75,871	80,265
266	Dawsonville	58,720	62,086	67,837	72,885	77,529	82,259	86,587	92,414	97,398
267	Hyattsville (Chillum)	27,825	28,389	29,201	30,083	31,206	32,088	33,028	33,927	34,860
268	College Park	21,450	21,892	22,937	24,000	25,249	26,358	27,376	28,376	29,463
269	Hyattsville (Edmonston)	23,495	23,980	24,642	25,312	26,226	27,007	27,849	28,537	29,309
270	Lanham (Landover Hills)	27,293	27,941	28,950	29,953	31,182	32,314	33,457	34,471	35,571
271	Fairmount Heights	27,474	27,982	28,725	29,482	30,466	31,243	32,134	32,908	33,738
272	Glenarden	24,838	25,335	26,054	26,794	27,734	28,516	29,364	30,120	30,927
273	District Heights	28,917	29,581	30,550	31,554	32,803	33,947	35,107	36,109	37,212
274	Marlow Heights	29,187	29,764	30,613	31,488	32,603	33,514	34,496	35,395	36,344
275	Upper Marlboro	43,373	44,475	46,129	47,814	49,586	51,514	53,117	54,885	56,629
276	Beltsville	35,180	35,992	37,152	38,329	39,764	40,990	42,040	43,390	44,627
277	NASA Goddard Space Flight Center	33,156	33,921	35,047	36,216	37,633	39,004	39,991	41,310	42,551
278	Bowie	40,252	41,204	42,565	43,964	45,331	47,000	48,182	49,706	51,128
279	Woodmore	46,228	47,639	49,695	51,881	53,926	56,524	58,349	60,638	62,815

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
280	Cheltenham	39,878	40,949	42,532	44,099	45,592	47,365	48,597	50,374	51,941
281	Fort Washington	38,513	39,545	41,093	42,736	44,302	46,296	47,729	49,410	51,065
282	Severn	37,756	39,657	42,985	46,433	49,368	51,978	55,432	58,625	61,764
283	Odenton	39,943	41,683	44,499	48,139	51,420	55,649	59,366	62,171	65,654
284	Crofton	46,359	47,869	51,604	54,171	56,599	58,749	61,756	64,654	67,380
285	Crownsville	58,364	60,534	63,894	67,397	69,352	71,359	74,372	77,765	80,561
286	Davidsonville	53,953	56,028	59,582	63,392	66,826	69,855	72,221	76,395	79,743
287	Galesville	46,336	48,132	51,166	55,053	58,270	60,707	64,627	67,663	70,919
288	Riviera Beach	38,267	39,973	42,961	45,980	49,154	52,099	55,104	58,084	61,109
289	Annapolis - Cape St. Clair	47,273	48,862	51,594	54,422	57,400	60,424	63,258	65,991	68,863
290	Pasadena (Millersville)	43,439	44,972	47,560	50,142	52,691	55,112	57,425	60,120	62,635
291	Linthicum Heights	29,045	30,622	33,288	36,065	39,026	41,818	44,639	47,322	50,121
292	Glenmore	29,810	30,825	32,515	34,144	35,782	37,383	38,779	40,569	42,184
293	Baltimore Washington International Airport	2,022	2,088	2,189	2,280	2,343	2,401	2,464	2,574	2,653
294	Fort Meade-Patuxent Research Refuge	32,513	35,511	38,986	42,762	47,042	51,929	54,759	59,301	63,310
295	Hanover	26,623	30,534	37,352	42,185	47,485	54,395	58,249	65,060	70,762
296	Edgewood	32,204	33,014	35,731	38,587	40,839	42,873	43,043	46,440	48,592
297	Bel Air	39,426	39,983	42,949	46,037	48,453	49,674	50,045	53,502	55,637
298	Aberdeen	34,298	35,461	39,173	43,169	46,366	49,883	49,801	54,652	57,749
299	Catonsville - Halethorpe	30,759	31,747	33,354	34,874	36,810	38,705	39,744	41,656	43,311

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
300	Randallstown	33,469	35,386	38,570	41,628	44,911	47,341	47,908	52,318	55,061
301	Reisterstown	35,371	36,906	39,233	41,375	43,042	44,623	45,363	48,307	50,137
302	Brooklandville	62,941	66,182	71,263	76,070	79,693	83,230	83,955	90,779	94,705
303	Towson	35,426	36,702	38,742	40,458	42,512	44,295	45,240	47,697	49,500
304	Hereford	50,844	53,339	57,205	60,874	63,668	66,357	66,921	72,139	75,141
305	Perry Hall	40,677	42,525	45,358	47,975	49,987	51,907	52,370	56,146	58,320
306	Rosedale-Rossville	27,110	28,129	29,775	31,361	33,381	35,412	36,502	38,468	40,199
307	Frederick	38,240	39,699	42,092	44,480	46,814	49,274	51,786	54,110	56,518
308	Thurmont	36,100	37,555	39,907	42,236	44,476	46,837	49,222	51,540	53,872
309	Sterling	47,014	47,924	49,437	51,146	52,716	54,226	55,658	57,306	58,867
310	Ashburn South	50,333	52,669	56,553	59,773	63,455	67,140	70,914	74,518	78,158
311	Leesburg	46,391	48,721	51,340	54,216	57,464	61,245	65,137	67,802	71,058
312	Purcellville	51,578	52,586	53,464	54,579	56,254	57,972	59,728	60,733	62,147
313	Herndon - Reston	56,781	59,713	64,468	69,431	74,600	79,918	84,278	89,407	94,375
314	Centreville	50,395	52,957	57,611	62,331	67,124	71,057	75,146	80,011	84,494
315	Fairfax	48,044	50,357	54,286	58,504	63,084	67,435	71,769	75,728	79,994
316	Vienna	58,980	61,955	66,330	71,040	76,064	81,428	86,254	90,859	95,730
317	Seven Corners	44,734	46,453	49,636	52,289	55,147	58,137	60,539	63,670	66,518
318	Springfield	43,401	44,838	47,506	50,035	52,689	54,873	57,433	60,011	62,527
319	Huntington	45,106	46,321	48,589	50,523	52,537	54,637	56,206	58,514	60,526

Zone ID	Zone Name	2012	2015	2020	2025	2030	2035	2040	2045	2050
320	McLean	82,636	88,614	96,334	104,938	111,595	119,316	125,921	135,035	142,722
321	Great Falls	88,901	93,537	99,642	107,771	112,992	118,450	123,003	131,069	137,231
322	Warrenton	41,943	43,787	46,761	49,737	52,738	55,738	58,739	61,732	64,728
323	Dale City	35,897	37,082	39,094	40,980	42,860	44,712	46,562	48,555	50,459
324	Manassas	34,729	35,789	37,377	39,019	40,732	42,381	44,050	45,711	47,371
325	Haymarket	43,407	45,299	48,722	52,196	55,866	59,484	63,214	66,458	70,007
326	Stafford	36,907	38,086	40,015	41,943	43,868	45,791	47,712	49,652	51,581
327	200-KGC01-King George	35,132	36,083	37,655	39,227	40,800	42,372	43,944	45,518	47,091
328	Columbia	46,827	48,206	50,909	53,510	55,836	58,015	60,370	62,978	65,413
329	Ellicott City	49,339	51,369	54,082	56,881	59,714	62,383	65,278	68,205	71,016
330	Elkridge	41,793	43,830	47,127	50,875	54,369	57,533	61,021	64,499	67,948
331	Peninsula Laurel-Savage	41,478	42,845	44,669	46,922	49,269	51,491	53,252	55,553	57,687
332	Clarksville	69,070	73,166	79,205	85,716	93,745	101,377	110,088	115,734	122,983
333	Cooksville	55,192	57,898	62,068	65,225	68,532	72,404	76,054	79,947	83,598

APPENDIX B: COMPASS™ MODEL

The COMPASS™ Model System is a flexible multimodal demand-forecasting tool that provides comparative evaluations of alternative socioeconomic and network scenarios. It also allows input variables to be modified to test the sensitivity of demand to various parameters such as elasticities, values of time, and values of frequency. This section describes in detail the model methodology and process used in the study.

1. DESCRIPTION OF THE COMPASS™ MODEL SYSTEM

The COMPASS™ model is structured on two principal models: Total Demand Model and Hierarchical Modal Split Model. For this study, these two models were calibrated separately for three trip purposes, which are Business, Commuter, and Social. For each market segment, the models were calibrated on base year origin-destination trip data, existing network characteristics and base year socioeconomic data.

Since the models were calibrated on the base year data, when applying the models for forecasting, an incremental approach known as the "pivot point" method is used. By applying model growth rates to the base data observations, the "pivot point" method is able to preserve the unique travel flows present in the base data that are not captured by the model variables. Details on how this method is implemented are described below.

2. TOTAL DEMAND MODEL

The Total Demand Model, shown in Equation 1, provides a mechanism for assessing overall growth in the travel market.

Equation 1:

$$T_{ijp} = e^{\beta 0p}(SE_{ijp})^{\beta 1p} e^{\beta 2p\, U ijp}$$

Where,

T_{ijp}	=	Number of trips between zones *i* and *j* for trip purpose *p*
SE_{ijp}	=	Socioeconomic variables for zones *i* and *j* for trip purpose *p*
U_{ijp}	=	Total utility of the transportation system for zones *i* to *j* for trip purpose *p*
$\beta_{0p}, \beta_{1p}, \beta_{2p}$	=	Coefficients for trip purpose *p*

As shown in Equation 1, the total number of trips between any two zones for all modes of travel, segmented by trip purpose, is a function of the socioeconomic characteristics of the zones and the total utility of the transportation system that exists between the two zones. For this study, trip purposes include Business, Commuter, and Social. The socioeconomic characteristics consist of population, employment and per capita income. The utility function provides a measure of the quality of the transportation system in terms of the times, costs, reliability and level of service provided by all modes for a given trip purpose. The Total Demand Model equation may be interpreted as meaning that travel between zones will increase as socioeconomic factors such as population and income rise or as the utility (or quality) of the transportation system is improved by providing new facilities and services that reduce travel times and/or costs. The Total Demand Model can therefore be used to evaluate the effect of changes in both socioeconomic and travel characteristics on the total demand for travel.

2.1 SOCIOECONOMIC VARIABLES

The socioeconomic variables in the Total Demand Model show the impact of economic growth on travel demand. The COMPASS™ Model System, in line with most intercity modeling systems, uses three variables (population, employment, and per household income) to represent the socioeconomic characteristics of a zone. Different combinations were tested in the calibration process and it was found, as is typically found elsewhere, that the most reasonable and statistically stable relationships consists of the following formulations:

Trip Purpose	*Socioeconomic Variable*
Business	$E_i E_j (I_i + I_j) / 2$
Commuter	$(P_i E_j + P_j E_i) / 2 (I_i + I_j) / 2$
Social	$P_i P_j (I_i + I_j) / 2$

The Business formulation consists of a product of employment in the origin zone, employment in the destination zone, and the average per capita income of the two zones. Since business trips are usually made between places of work, the presence of employment in the formulation is reasonable. While the income factor is correlated to the type of employment, higher income levels generate more Business trips. The Commuter formulation consists of all socioeconomic factors, this is because commuter trips are between homes and places of work, which are closely related to population and employment, and income factor is related to the wealth of the origin zone and the type of employment in the destination zone. The formulation for Social trip purposes such as leisure and tourist trip consists of a product of population in the origin zone, population in the destination zone and the average per capita income of the two zones. Other trip purposes encompass many types of trips, but the majority is home-based and thus, greater volumes of trips are expected from zones with higher population and income.

2.2 TRAVEL UTILITY

Estimates of travel utility for a transportation network are generated as a function of generalized cost (GC), as shown in Equation 2:

Equation 2:

$$U_{ijp} = f(GC_{ijp})$$

where,

GC_{ijp} = Generalized Cost of travel between zones *i* and *j* for trip purpose *p*

Because the generalized cost variable is used to estimate the impact of improvements in the transportation system on the overall level of trip making, it needs to incorporate all the key attributes that affect an individual's decision to make trips. For the public modes (i.e., rail and bus), the generalized cost of travel includes all aspects of travel time (access, egress, in-vehicle times), travel cost (fares), and schedule convenience (frequency of service, convenience of arrival/departure times). For auto travel, full average cost of operating a car is used for Business, while only the marginal cost is used for Commuter and Social trips. In addition, tolls and parking charges are used where appropriate.

The generalized cost of travel is typically defined in travel time (i.e., minutes) rather than dollars. Costs are converted to time by applying appropriate conversion factors, as shown in Equation 3. The generalized cost (GC) of travel between zones i and j for mode m and trip purpose p is calculated as follows:

Equation 3:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} + \frac{VOF_{mp} * OH * \ln(\alpha * F_{ijm})}{VOT_{mp} * \beta * F_{ijm}^2}$$

Where,

TT_{ijm} = Travel Time between zones *i* and *j* for mode *m* (in-vehicle time + station wait time + connection wait time + access/egress time + interchange penalty), with waiting, connect and access/egress time multiplied by a factor (greater than 1) to account for the additional disutility felt by travelers for these activities

TC_{ijmp} = Travel Cost between zones *i* and *j* for mode *m* and trip purpose *p* (fare + access/egress cost for public modes, operating costs for auto)

VOT_{mp} = Value of Time for mode *m* and trip purpose *p*

VOF_{mp} = Value of Frequency for mode *m* and trip purpose *p*

F_{ijm} = Frequency in departures per week between zones *i* and *j* for mode *m*

a, β = Frequency damping factors, a=0.191, β=0.074

OH = Operating hours per week

Station wait time is the time spent at the station before departure and after arrival. On trips with connections, there would be additional wait times incurred at the connecting station. Wait times are weighted higher than in-vehicle time in the generalized cost formula to reflect their higher disutility as found from previous studies. Wait times are weighted 70 percent higher than in-vehicle time.

Similarly, access/egress time has a higher disutility than in-vehicle time. Access time tends to be more stressful for the traveler than in-vehicle time because of the uncertainty created by trying to catch the flight or train. Based on previous work, access time is weighted 80 percent higher for rail and bus travel.

The third term in the generalized cost function converts the frequency attribute into time units. Operating hours divided by frequency is a measure of the headway or time between departures. Tradeoffs are made in the stated preference surveys resulting in the value of frequencies on this measure. Although there may appear to some double counting because the station wait time in the first term of the generalized cost function is included in this headway measure, it is not the headway time itself that is being added to the generalized cost. The third term represents the impact of perceived frequency valuations on generalized cost. TEMS has found it very effective to measure this impact as a function of the headway.

2.3 Calibration of the Total Demand Model

In order to calibrate the Total Demand Model, the coefficients are estimated using linear regression techniques. Equation 1, the equation for the Total Demand Model, is transformed by taking the natural logarithm of both sides, as shown in Equation 4:

Equation 4:

$$\log(T_{ijp}) = \beta_{0p} + \beta_{1p} \log(SE_{ijp}) + \beta_{2p}(U_{ijp})$$

Equation 4 provides the linear specification of the model necessary for regression analysis.

The segmentation of the database by trip purpose resulted in two sets of models. The results of the calibration for the Total Demand Models are displayed in Exhibit B-1.

Exhibit B-1: Total Demand Model Coefficients (1)

Business	$\log(T_{ij})$	=	-4.5027	+	0.3455 $\ln(SE_{ij})$	+	0.0309 U_{ij}	R^2=0.74
			(-132)		(288)		(39)	
	where $U_{ij} = \log[\exp(-6.9370+0.9971U_{Public}) + \exp(-0.0316\ GC_{Auto})]$							
Commuter	$\log(T_{ij})$	=	-2.8057	+	0.2992 $\ln(SE_{ij})$	+	0.0326 U_{ij}	R^2=0.70
			(-82)		(252)		(34)	
	where $U_{ij} = \log[\exp(-4.7605+0.9992U_{Public}) + \exp(-0.0303\ GC_{Auto})]$							
Social	$\log(T_{ij})$	=	-1.9887	+	0.2938 $\ln(SE_{ij})$	+	0.0914 U_{ij}	R^2=0.68
			(-56)		(254)		(53)	
	where $U_{ij} = \log[\exp(-0.2406+0.9857U_{Public}) + \exp(-0.0054\ GC_{Auto})]$							

(1) *t-statistics are given in parentheses.*

In evaluating the validity of a statistical calibration, there are two key statistical measures: t-statistics and R2. The t-statistics are a measure of the significance of the model's coefficients; values of 1.95 and above are considered "good" and imply that the variable has significant explanatory power in estimating the level of trips. R2 is a statistical measure of the "goodness of fit" of the model to the data; any data point that deviates from the model will reduce this measure. It has a range from 0 to a perfect 1, with 0.3 and above considered "good" for large data sets. Based on these two measures, the total demand calibrations are good. The t-statistics are high, aided by the large size of the data set. The R2 values imply good fits of the equations to the data.

As shown in Exhibit B-1, the socioeconomic elasticity values for the Total Demand Model are 0.34 and 0.29 for business and non-business trips, meaning that each one percent growth in the socioeconomic term generates approximately a 0.34 and 0.29 percent growth in the total business and non-business travel market respectively.

The coefficient on the utility term is not strictly elasticity, but it can be considered an approximation. The utility term is related to the scale of the generalized costs, for example, utility elasticity can be high if the absolute value of transportation utility improvement is significant. This is not untypical when new transportation systems are built. In these cases, a 20 percent reduction in utility is not unusual and may impact more heavily on longer origin-destination pairs than shorter origin-destination pairs.

2.4 Incremental Form of the Total Demand Model

The calibrated Total Demand Models could be used to estimate the total travel market for any zone pair using the population, employment, per household income, and the total utility of all the modes. However, there would be significant differences between estimated and observed levels of trip making for many zone pairs despite the good fit of the models to the data. To preserve the unique travel patterns contained in the base data, the incremental approach or "pivot point" method is used for forecasting. In the incremental approach, the base travel data assembled in the database are used as pivot points, and

forecasts are made by applying trends to the base data. The total demand equation as described in Equation 1 can be rewritten into the following incremental form that can be used for forecasting (Equation 5):

Equation 5:

$$\frac{T_{ijp}^{\ f}}{T_{ijp}^{\ b}} = \left(\frac{SE_{ijp}^{\ f}}{SE_{ijp}^{\ b}}\right)^{\beta_{1p}} \exp(\beta_{2p}\,(U_{ijp}^{\ f} - U_{ijp}^{\ b}))$$

Where,

T^f_{ijp} = Number of Trips between zones *i* and *j* for trip purpose *p* in forecast year *f*

T^f_{ijp} = Number of Trips between zones *i* and *j* for trip purpose *p* in base year *b*

SE^f_{ijp} = Socioeconomic variables for zones *i* and *j* for trip purpose *p* in forecast year *f*

SE^b_{ijp} = Socioeconomic variables for zones *i* and *j* for trip purpose *p* in base year *b*

U^f_{ijp} = Total utility of the transportation system for zones *i* to *j* for trip purpose *p* in forecast year *f*

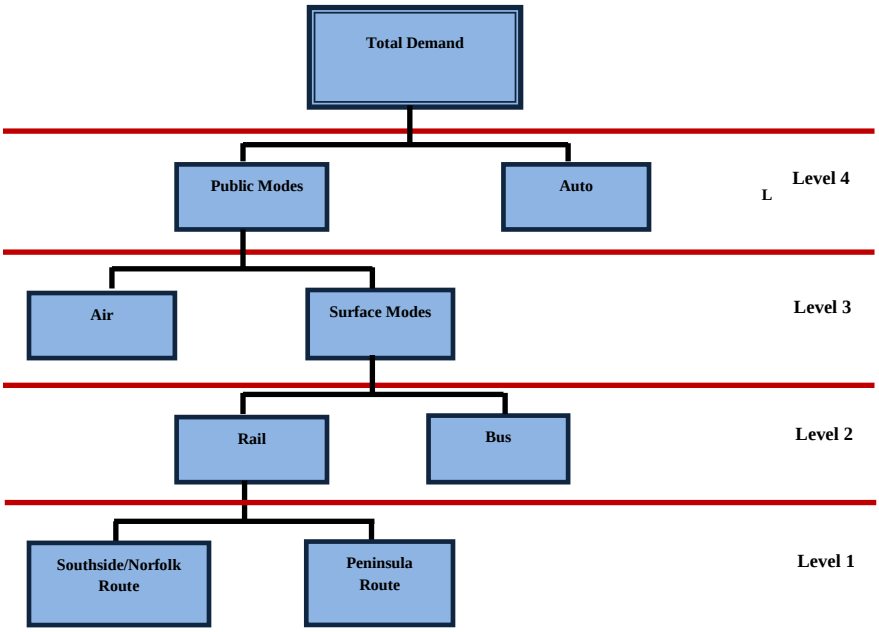
U^b_{ijp} = Total utility of the transportation system for zones *i* to *j* for trip purpose *p* in base year *b*

In the incremental form, the constant term disappears and only the elasticities are important.

3. HIERARCHICAL MODAL SPLIT MODEL

The role of the Hierarchical Modal Split Model is to estimate relative modal shares, given the Total Demand Model estimate of the total market that consists of different travel modes available to travelers. The relative modal shares are derived by comparing the relative levels of service offered by each of the travel modes. The COMPASS™ Hierarchical Modal Split Model uses a nested logit structure, which has been adapted to model the interurban modal choices available in the study area. The hierarchical modal split model is shown in Exhibit B-2.

Exhibit B-2: Hierarchical Structure of the Modal Split Model

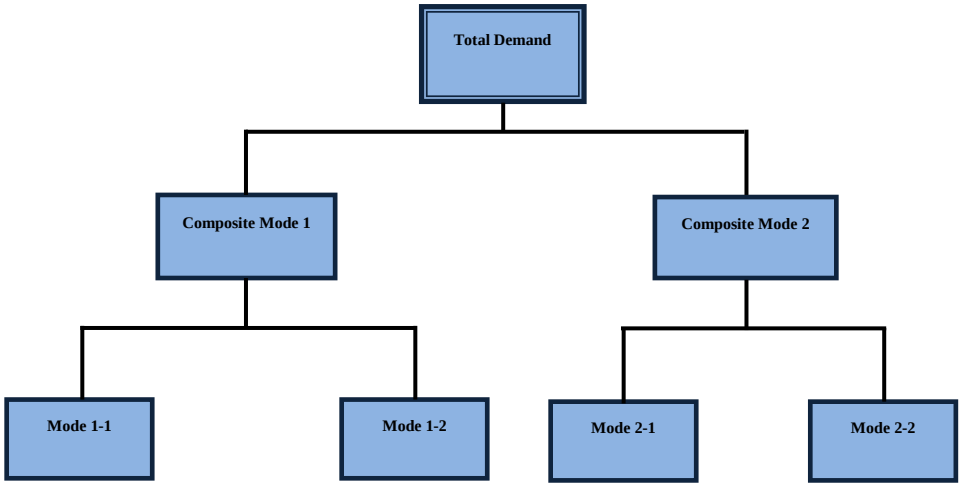


The main feature of the Hierarchical Modal Split Model structure is the increasing commonality of travel characteristics as the structure descends. The upper level of the hierarchy separates private auto travel – with its spontaneous frequency, low access/egress times, low costs and highly personalized characteristics – from the public modes. The lower separates Maglev – a faster and more comfortable public mode from Transit, which provides slower conventional rail and bus services within the corridor.

3.1 Background of the Hierarchical Modal Split Theory

The modal split models used by TEMS derived from the standard nested logit model. Exhibit B-3 shows a typical two-level standard nested model. In the nested model shown in Exhibit B-3, there are four travel modes that are grouped into two composite modes, namely, Composite Mode 1 and Composite Mode 2.

Exhibit B-3: A Typical Standard Nested Logit Model



Each travel mode in the above model has a utility function of Uj, j = 1, 2, 3, 4. To assess modal split behavior, the logsum utility function, which is derived from travel utility theory, has been adopted for the composite modes in the model. As the modal split hierarchy ascends, the logsum utility values are derived by combining the utility of lower-level modes. The composite utility is calculated by

$$U_{N_k} = \alpha_{N_k} + \beta_{N_k} \log \sum_{i \in N_k} \exp(\rho U_i) \qquad (1)$$

where

N_k is composite mode k in the modal split model,

i is the travel mode in each nest,

U_i is the utility of each travel mode in the nest,

ρ is the nesting coefficient.

The probability that composite mode k is chosen by a traveler is given by

$$P(N_k) = \frac{\exp(U_{N_k} / \rho)}{\sum_{N_i \in N} \exp(U_{N_i} / \rho)} \qquad (2)$$

The probability of mode i in composite mode k being chosen is

$$P_{N_k}(i) = \frac{\exp(\rho U_i)}{\sum_{j \in N_k} \exp(\rho U_j)} \qquad (3)$$

A key feature of these models is a use of utility. Typically in transportation modeling, the utility of travel between zones i and j by mode m for purpose p is a function of all the components of travel time, travel cost, terminal wait time and cost, parking cost, etc. This is measured by generalized cost developed for each origin-destination zone pair on a mode and purpose basis. In the model application, the utility for each mode is estimated by calibrating a utility function against the revealed base year mode choice and generalized cost.

Using logsum functions, the generalized cost is then transformed into a composite utility for the composite mode (e.g. Public modes in Exhibit B-2). This is then used at the next level of the hierarchy to compare the next most similar mode choice (e.g. in Exhibit B-2, Public mode is compared with Auto mode).

3.2 Calibration of the Hierarchical Modal Split Model

Working from the lower level of the hierarchy to the upper level, the first analysis is that of the Rail mode versus the Bus mode. As shown in Exhibit B-4, the model was effectively calibrated for three trip purposes, with reasonable parameters and R2 and t values. All the coefficients have the correct signs such that demand increases or decreases in the correct direction as travel times or costs are increased or decreased, and all the coefficients appear to be reasonable in terms of the size of their impact.

Exhibit B-4: Rail Southside/Norfolk Route versus Rail Peninsula Route Modal Split Model Coefficients (1)

Business	$\log(P_{Rail\ South}/P_{Rail\ Peninsula}) = 0.2286 - 0.0086\ GC_{Rail\ South} + 0.0090\ GC_{Rail\ Peninsula}$	$R^2=0.93$
	(61) (-686) (701)	
Commuter	$\log(P_{Rail\ South}/P_{Rail\ Peninsula}) = 0.1476 - 0.0059\ GC_{Rail\ South} + 0.0061\ GC_{Rail\ Peninsula}$	$R^2=0.93$
	(59) (-674) (680)	
Social	$\log(P_{Rail\ South}/P_{Rail\ Peninsula}) = 0.1815 - 0.0056\ GC_{Rail\ South} + 0.0058\ GC_{Rail\ Peninsula}$	$R^2=0.93$
	(65) (-679) (687)	

(1) *t-statistics are given in parentheses.*

The coefficients for the upper levels of the hierarchy of Rail mode versus Bus mode, Surface mode versus Air mode, and Public versus Auto mode are given in Exhibits B-5, B-6, and B-7 respectively. The utility of the composite modes is obtained by deriving the logsum of the utilities of lower level modes from the model. The model calibrations for both trip purposes are statistically significant, with good R2 and t values, and reasonable coefficients.

Exhibit B-5: Rail versus Bus Modal Split Model Coefficients (1)

Business	$\log(P_{Rail}/P_{Bus}) = 7.1339 + 0.8983\ U_{Rail} + 0.0037\ GC_{Bus}$	$R^2=0.93$
	(904) (515) (267)	
	where $U_{Rail} = \log[\exp(0.2286-0.0086GC_{Rail\ South}) + \exp(-0.0090\ GC_{Rail\ Peninsula})]$	
Commuter	$\log(P_{Rail}/P_{Bus}) = 4.0241 - 0.8914\ GC_{Rail} + 0.0029\ GC_{Bus}$	$R^2=0.81$
	(634) (385) (320)	
	where $U_{Rail} = \log[\exp(0.1476-0.0059GC_{Rail\ South}) + \exp(-0.0061\ GC_{Rail\ Peninsula})]$	
Social	$\log(P_{Rail}/P_{Bus}) = 4.0703 - 0.8988\ GC_{Rail} + 0.0020\ GC_{Bus}$	$R^2=0.62$
	(431) (288) (158)	
	where $U_{Rail} = \log[\exp(0.1815-0.0056GC_{Rail\ South}) + \exp(-0.0058\ GC_{Rail\ Peninsula})]$	

(1) *t-statistics are given in parentheses.*

Exhibit B-6: Surface versus Air Modal Split Model Coefficients (1)

Business $\log(P_{Surface}/P_{Air}) = -1.0862 + 0.9994\,U_{Surf} + 0.0077\,GC_{Air}$ $R^2=0.80$
(-31) (293) (206)
where $U_{Surf} = \log[\exp(7.1339 + 0.8983U_{Rail}) + \exp(-0.0037\,GC_{Bus})]$

Commuter $\log(P_{Surface}/P_{Air}) = -2.4982 + 0.9976\,U_{Surf} + 0.0063\,GC_{Air}$ $R^2=0.72$
(-77) (229) (188)
where $U_{Surf} = \log[\exp(4.0241+ 0.8914GC_{Rail}) + \exp(-0.0029\,GC_{Bus})]$

Social $\log(P_{Surface}/P_{Air}) = -1.9248 + 0.9963\,U_{Surf} + 0.0046\,GC_{Air}$ $R^2=0.73$
(-76) (246) (177)
where $U_{Surf} = \log[\exp(4.0703+ 0.8988GC_{Rail}) + \exp(-0.0020\,GC_{Bus})]$

(1) *t-statistics are given in parentheses.*

Exhibit B-7: Public versus Auto Modal Split Model Coefficients (1)

Business $\log(P_{Public}/P_{Auto}) = -6.9370 + 0.9971\,U_{Public} + 0.0316\,GC_{Auto}$ $R^2=0.96$
(-358) (106) (595)
where $U_{Public} = \log[\exp(-1.0862+0.9994U_{Surface}) + \exp(-0.0077\,GC_{Air})]$

Commuter $\log(P_{Public}/P_{Auto}) = -4.7605 + 0.9992\,U_{Public} + 0.0303\,GC_{Auto}$ $R^2=0.97$
(-153) (73) (625)
where $U_{Public} = \log[\exp(-2.4982+0.9976U_{Surface}) + \exp(-0.0063\,GC_{Air})]$

Social $\log(P_{Public}/P_{Auto}) = -0.2406 + 0.9857\,U_{Public} + 0.0054\,GC_{Auto}$ $R^2=0.85$
(-27) (211) (418)
where $U_{Public} = \log[\exp(-1.9248+0.9963U_{Surface}) + \exp(-0.0046\,GC_{Air})]$

(1) *t-statistics are given in parentheses.*

3.3 INCREMENTAL FORM OF THE MODAL SPLIT MODEL

Using the same reasoning as previously described, the modal split models are applied incrementally to the base data rather than imposing the model estimated modal shares. Different regions of the corridor may have certain biases toward one form of travel over another and these differences cannot be captured with a single model for the entire system. Using the "pivot point" method, many of these differences can be retained. To apply the modal split models incrementally, the following reformulation of the hierarchical modal split models is used (Equation 6):

Equation 6:

$$\frac{\left(\frac{P_A^f}{P_B^f}\right)}{\left(\frac{P_A^b}{P_B^b}\right)} = e^{\beta(GC_A^f - GC_B^b) + \gamma(GC_B^f - GC_B^b)}$$

For hierarchical modal split models that involve composite utilities instead of generalized costs, the composite utilities would be used in the above formula in place of generalized costs. Once again, the constant term is not used and the drivers for modal shifts are changed in generalized cost from base conditions.

Another consequence of the pivot point method is that it prevents possible extreme modal changes from current trip-making levels as a result of the calibrated modal split model, thus that avoid over- or under-estimating future demand for each mode.

4. INDUCED DEMAND MODEL

Induced demand refers to changes in travel demand related to improvements in a transportation system, as opposed to changes in socioeconomic factors that contribute to growth in demand. The quality or utility of the transportation system is measured in terms of total travel time, travel cost, and worth of travel by all modes for a given trip purpose. The induced demand model used the increased utility resulting from system changes to estimate the amount of new (latent) demand that will result from the implementation of the new system adjustments. The model works simultaneously with the mode split model coefficients to determine the magnitude of the modal induced demand based on the total utility changes in the system. It should be noted that the model will also forecast a reduction in trips if the quality of travel falls due to increased congestions, higher car operating costs, or increased tolls. The utility function is acting like a demand curve increasing or decreasing travel based on changes in price (utility) for travel. It assumes travel is a normal good and subject to the laws of supply and demand.

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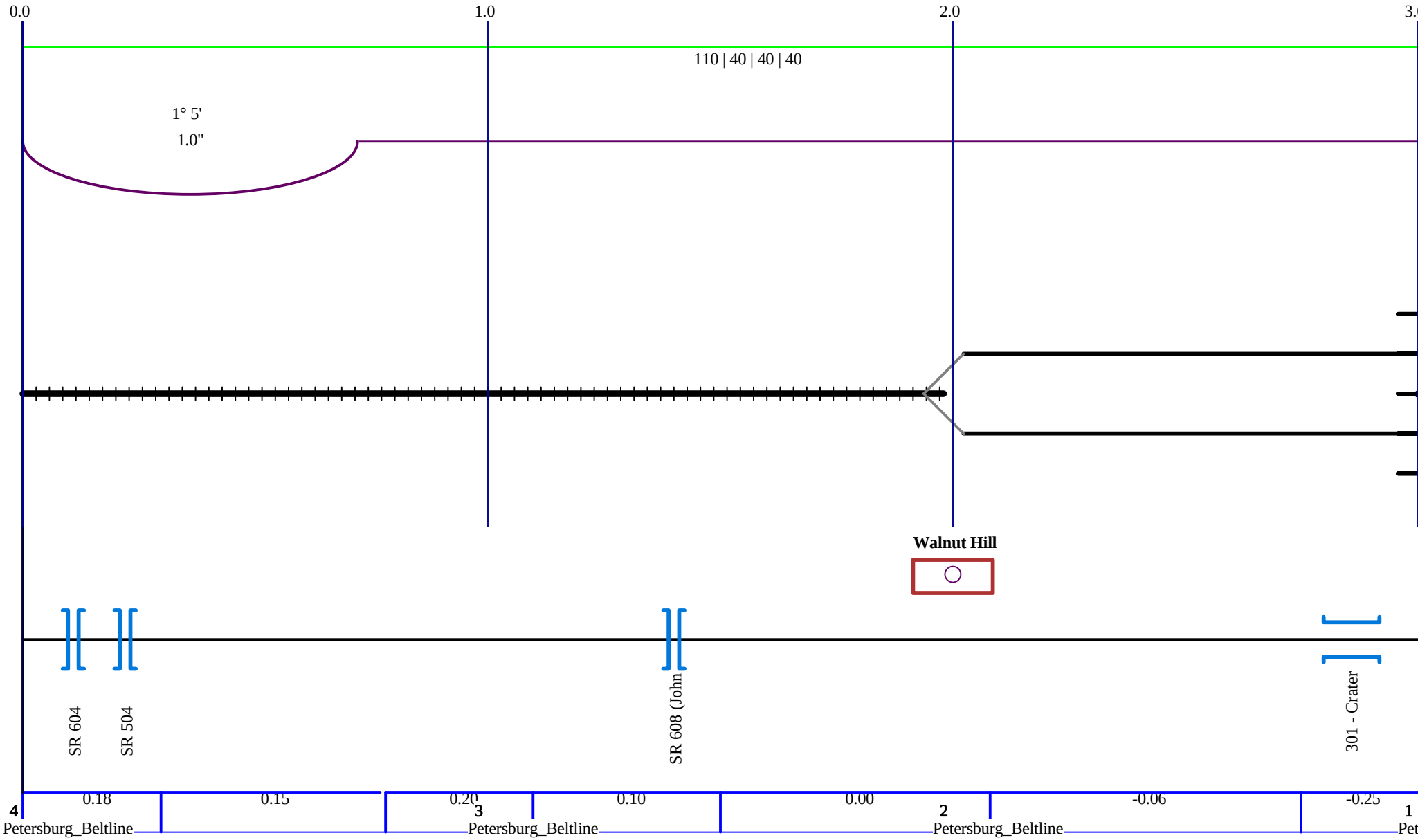
APPENDIX C – TRACKMAN™ FILES

1. NORFOLK SOUTHERN, PETERSBURG TO NORFOLK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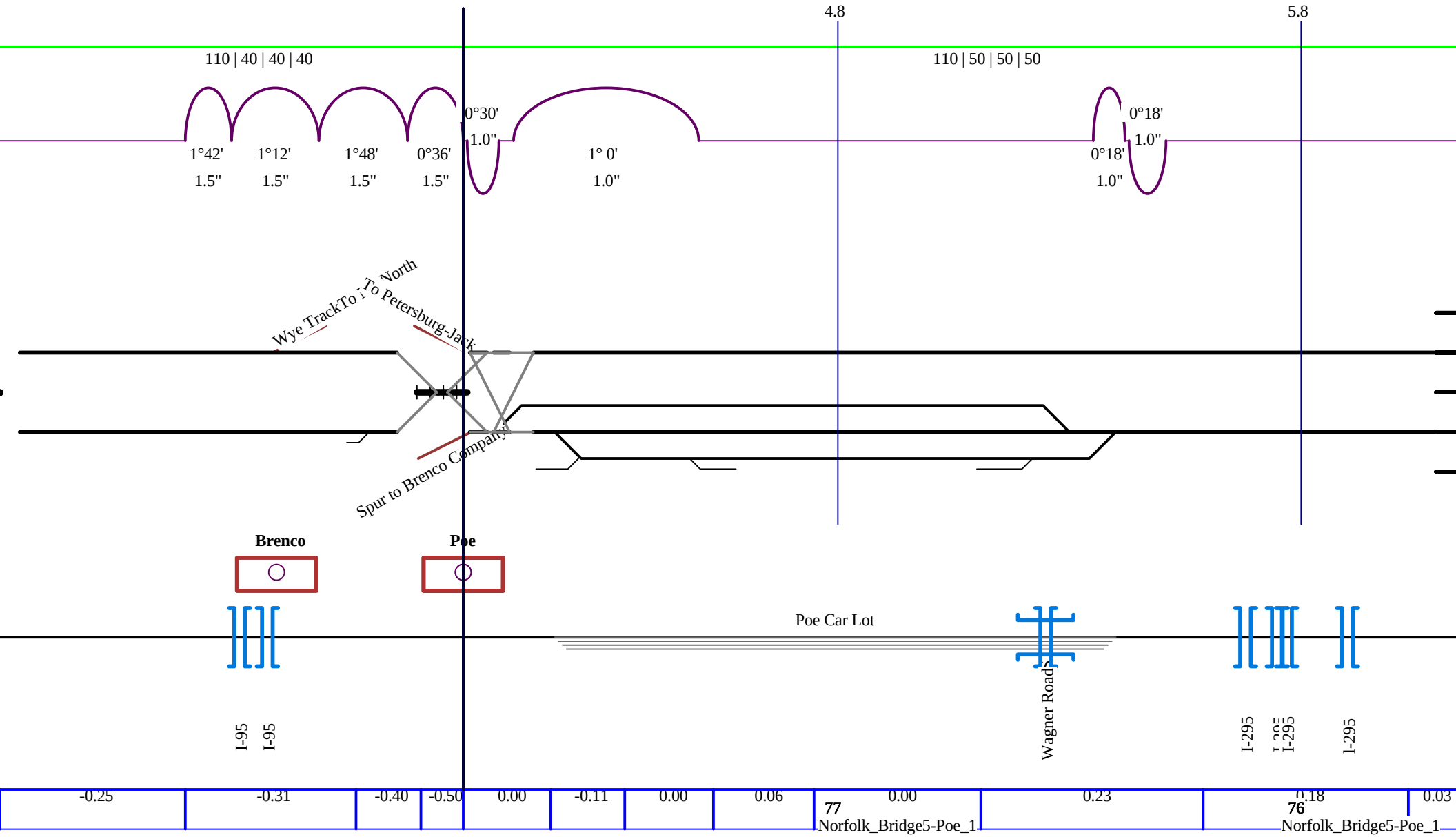
1.0
2.0
110 | 40 | 40 | 40
1° 5'
1.0"
Walnut Hill
SR 604
SR 504
SR 608 (John
301 - Crater
0.18
0.15
0.20
0.10
0.00
-0.06
-0.25
4
3
2
1
Petersburg_Beltline
Petersburg_Beltline
Petersburg_Beltline
Pet


4.8
5.8
110 | 40 | 40 | 40
110 | 50 | 50 | 50
0°30'
1.0"
1°42'
1.5"
1°12'
1.5"
1°48'
1.5"
0°36'
1.5"
1° 0'
1.0"
0°18'
1.0"
0°18'
1.0"
Wye TrackTo North
To Petersburg-Jack
Spur to Brenco Company
Brenco
Poe
Poe Car Lot
I-95
I-95
Wagner Road
I-295
I-295
I-295
-0.25
-0.31
-0.40
-0.50
0.00
-0.11
0.00
0.06
77
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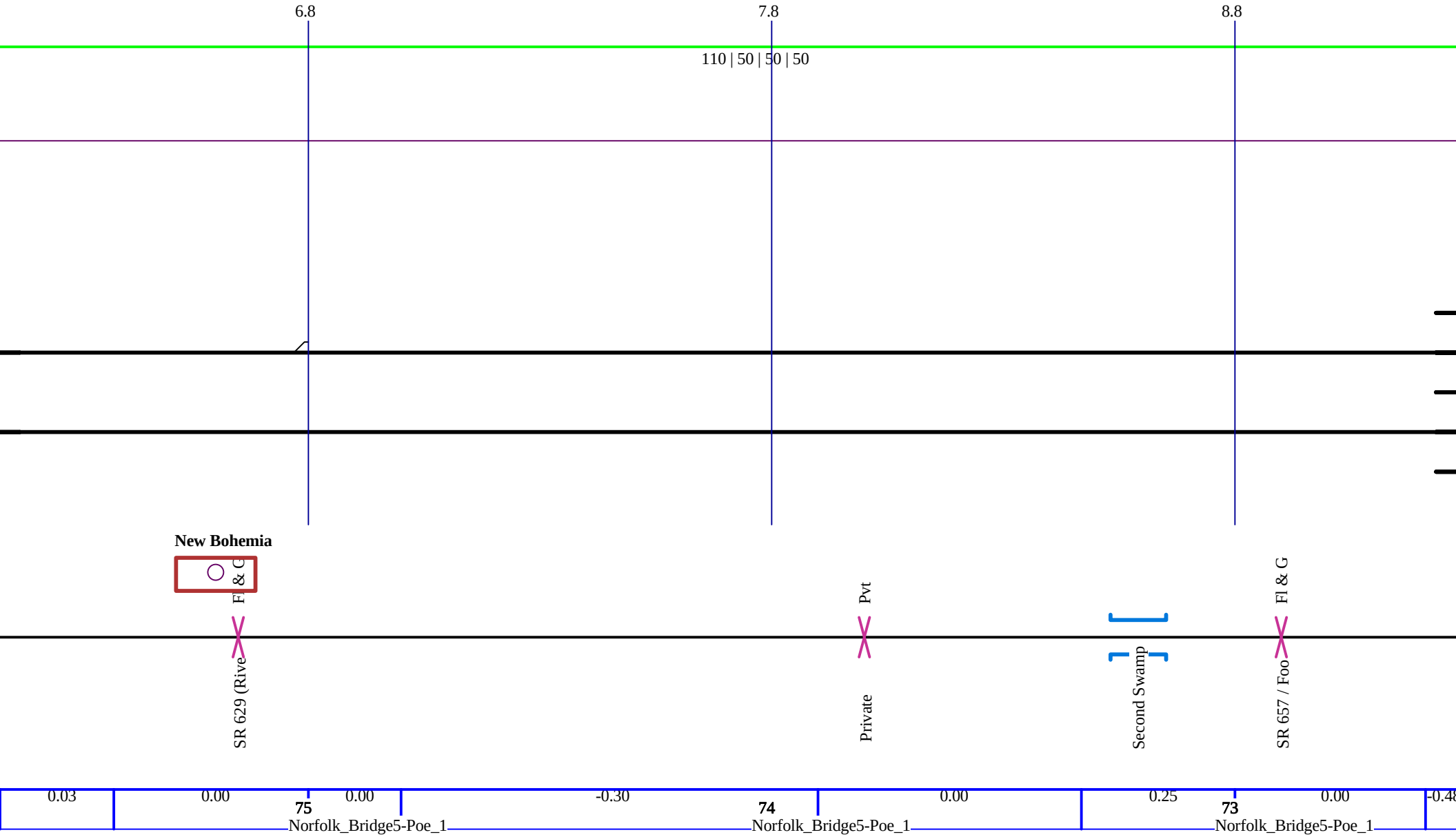
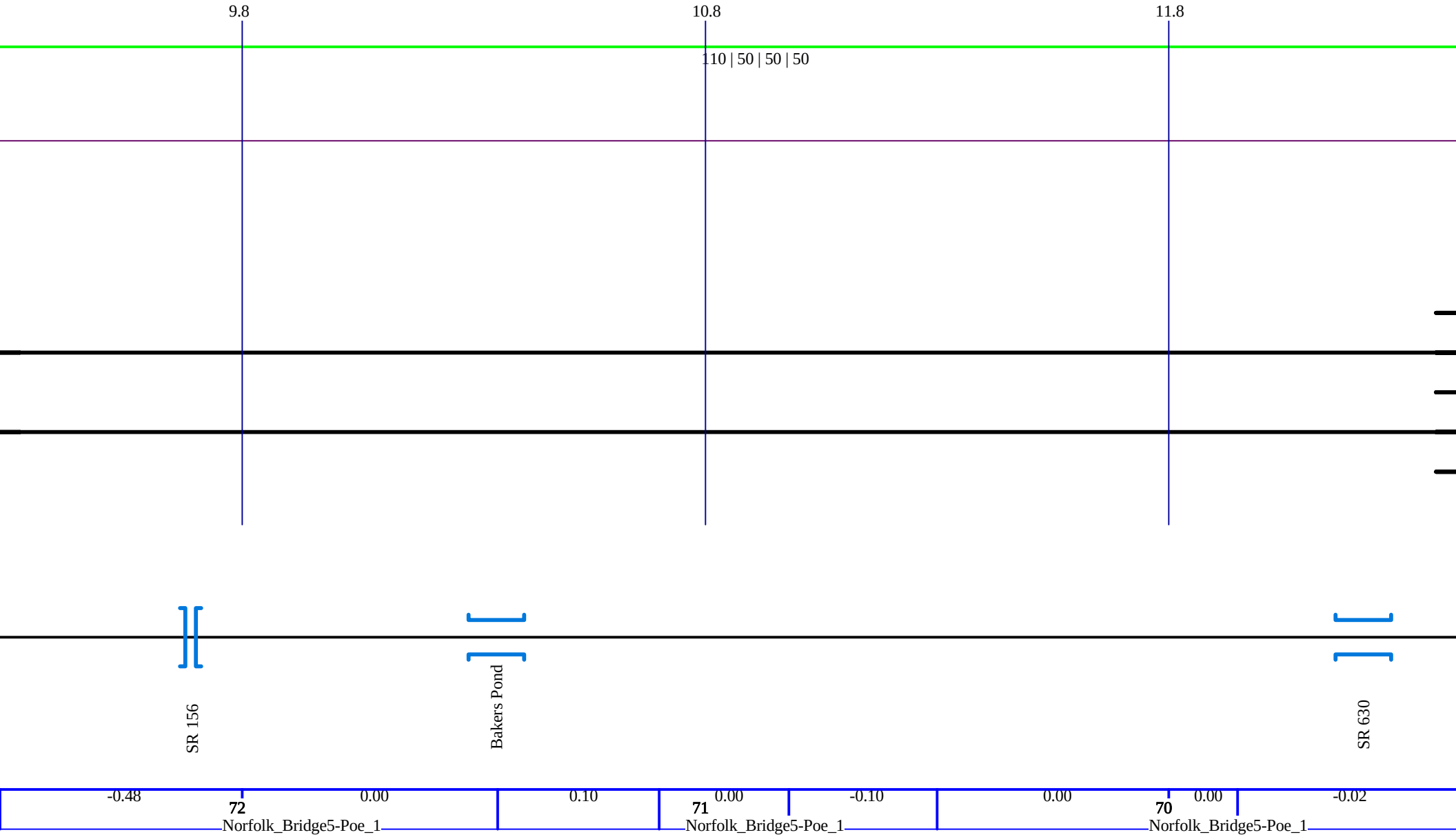
Norfolk_Bridge5-Poe_1
0.23
0.18
76
0.03
Norfolk_Bridge5-Poe_1


6.8
7.8
8.8
110 | 50 | 50 | 50
New Bohemia
Fl & G
SR 629 (Rive
Pvt
Private
Second Swamp
Fl & G
SR 657 / Foo
0.03
0.00
0.00
-0.30
0.00
0.25
0.00
75
74
73
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1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10.8
11.8
110 | 50 | 50 | 50
SR 156
Bakers Pond
SR 630
-0.48
72
0.00
0.10
71
0.00
-0.10
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-0.02
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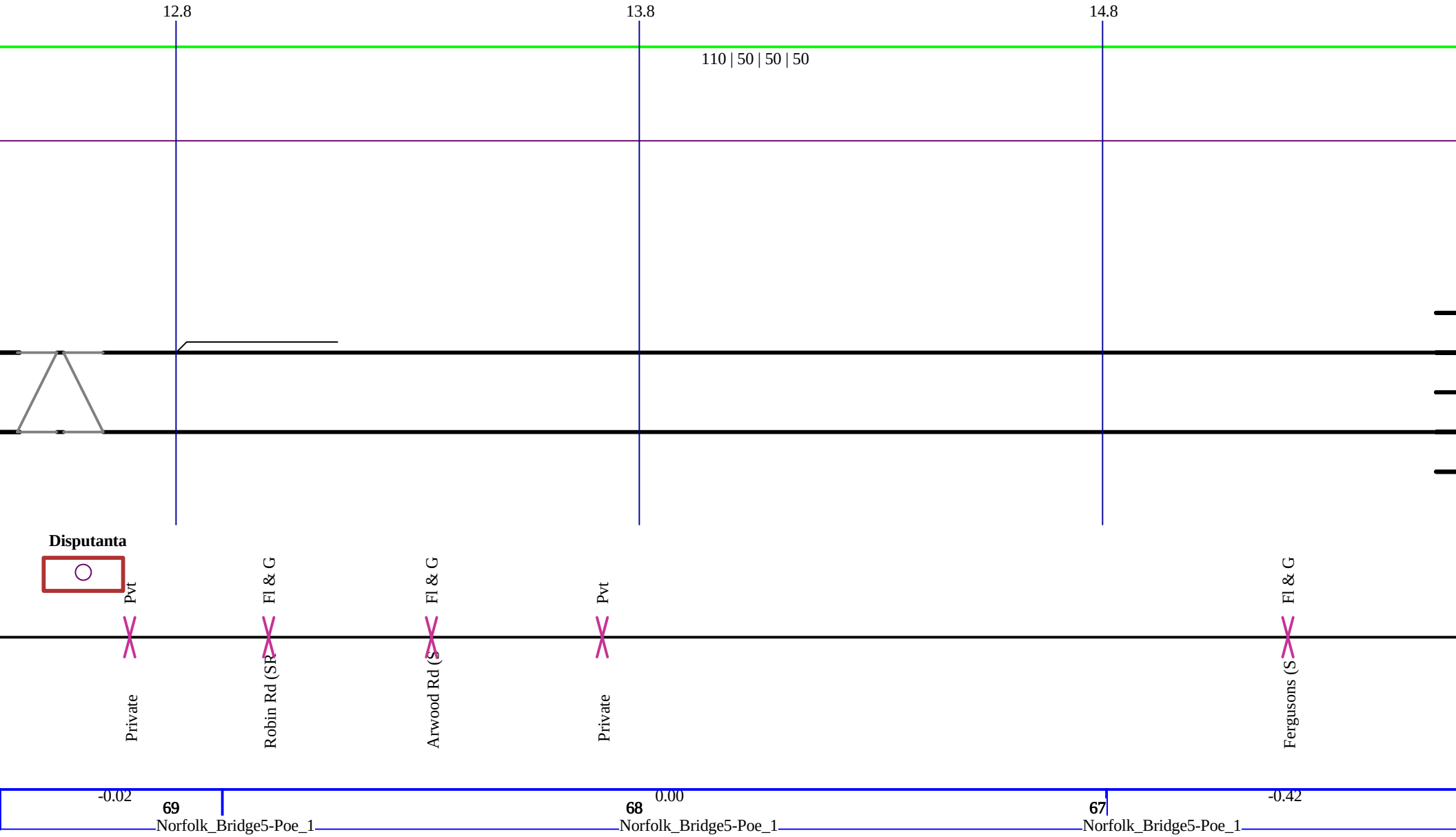
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1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13.8
14.8
110 | 50 | 50 | 50
Disputanta
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Fl & G
Fl & G
Pvt
Fl & G
Private
Robin Rd (SR
Arwood Rd (S
Private
Fergusons (S
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0.00
-0.42
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67
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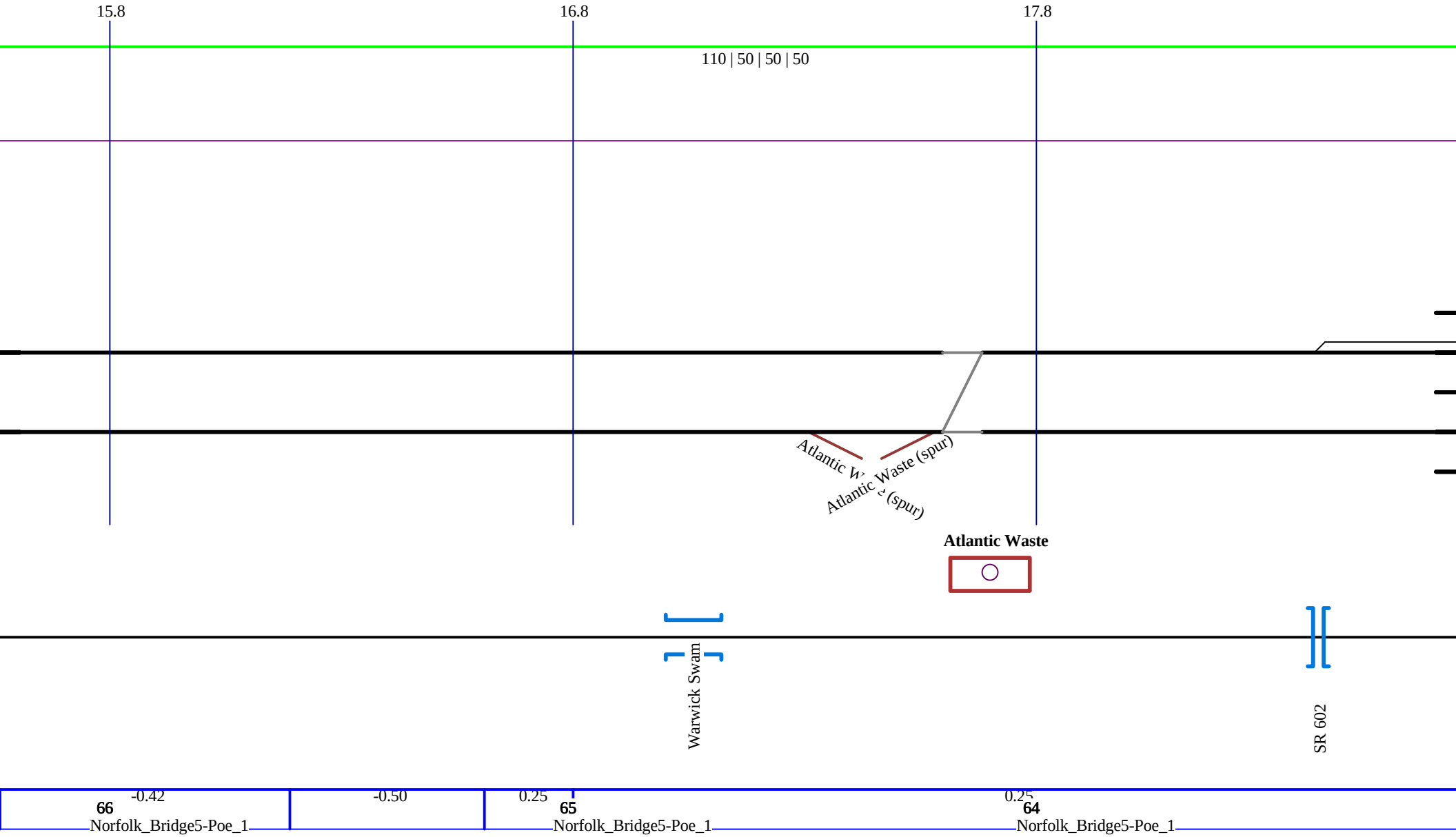
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1


15.8
16.8
17.8
110 | 50 | 50 | 50
Atlantic Waste (spur)
Atlantic Waste
Warwick Swam
SR 602
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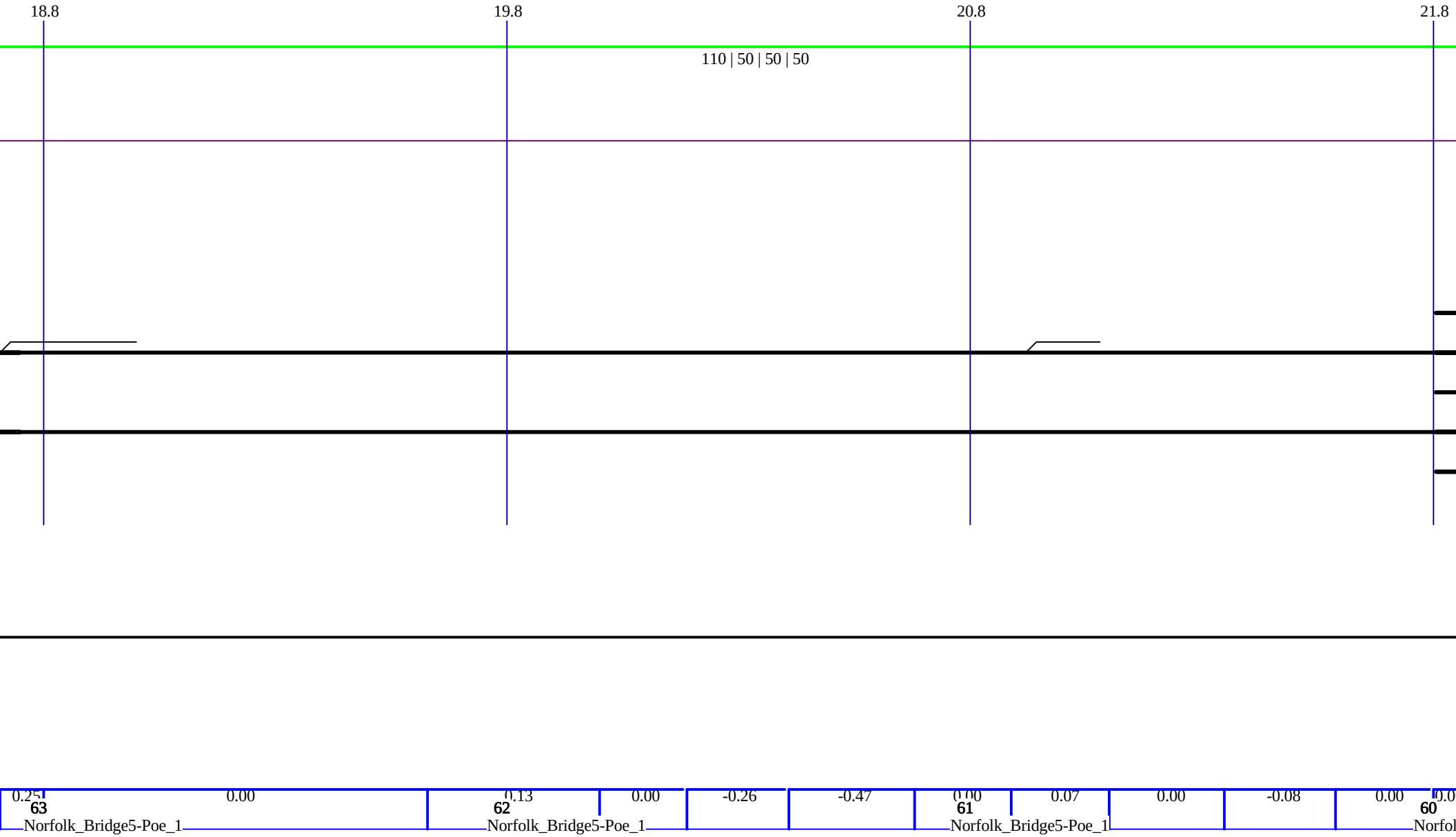
0.25
66
65
64
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1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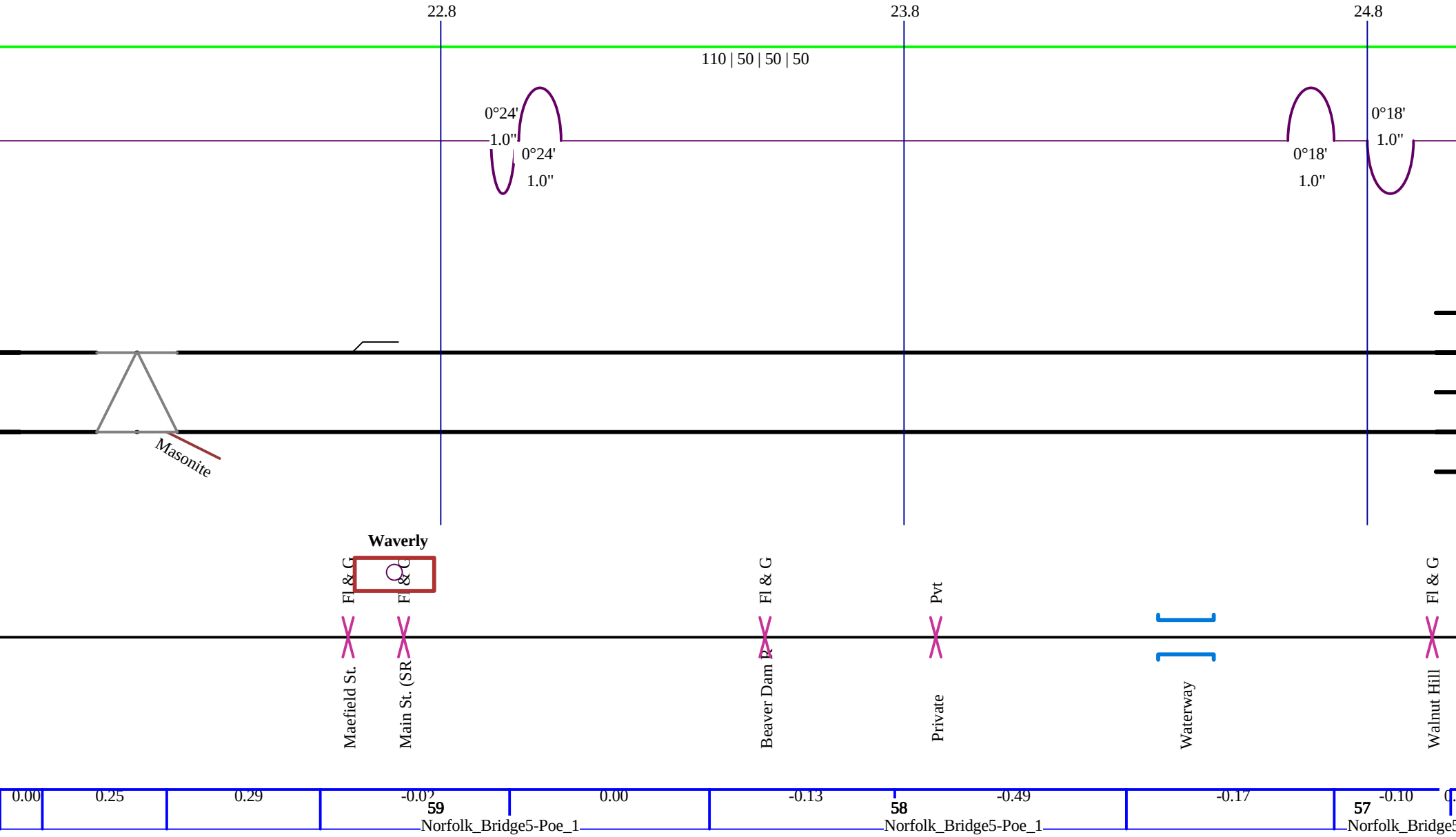
19.8
20.8
21.8
110 | 50 | 50 | 50
0.25
0.00
0.13
0.00
-0.26
-0.47
0.00
0.07
0.00
-0.08
0.00
0.0
63
Norfolk_Bridge5-Poe_1
62
Norfolk_Bridge5-Poe_1
61
Norfolk_Bridge5-Poe_1
60
Norfol


22.8
23.8
24.8
110 | 50 | 50 | 50
0°24'
1.0"
0°24'
1.0"
0°18'
1.0"
0°18'
1.0"
Masonite
Waverly
Fl & G
Fl & G
Fl & G
Pvt
Fl & G
Maefield St.
Main St. (SR
Beaver Dam R
Private
Waterway
Walnut Hill
0.00
0.25
0.29
-0.0
59
0.00
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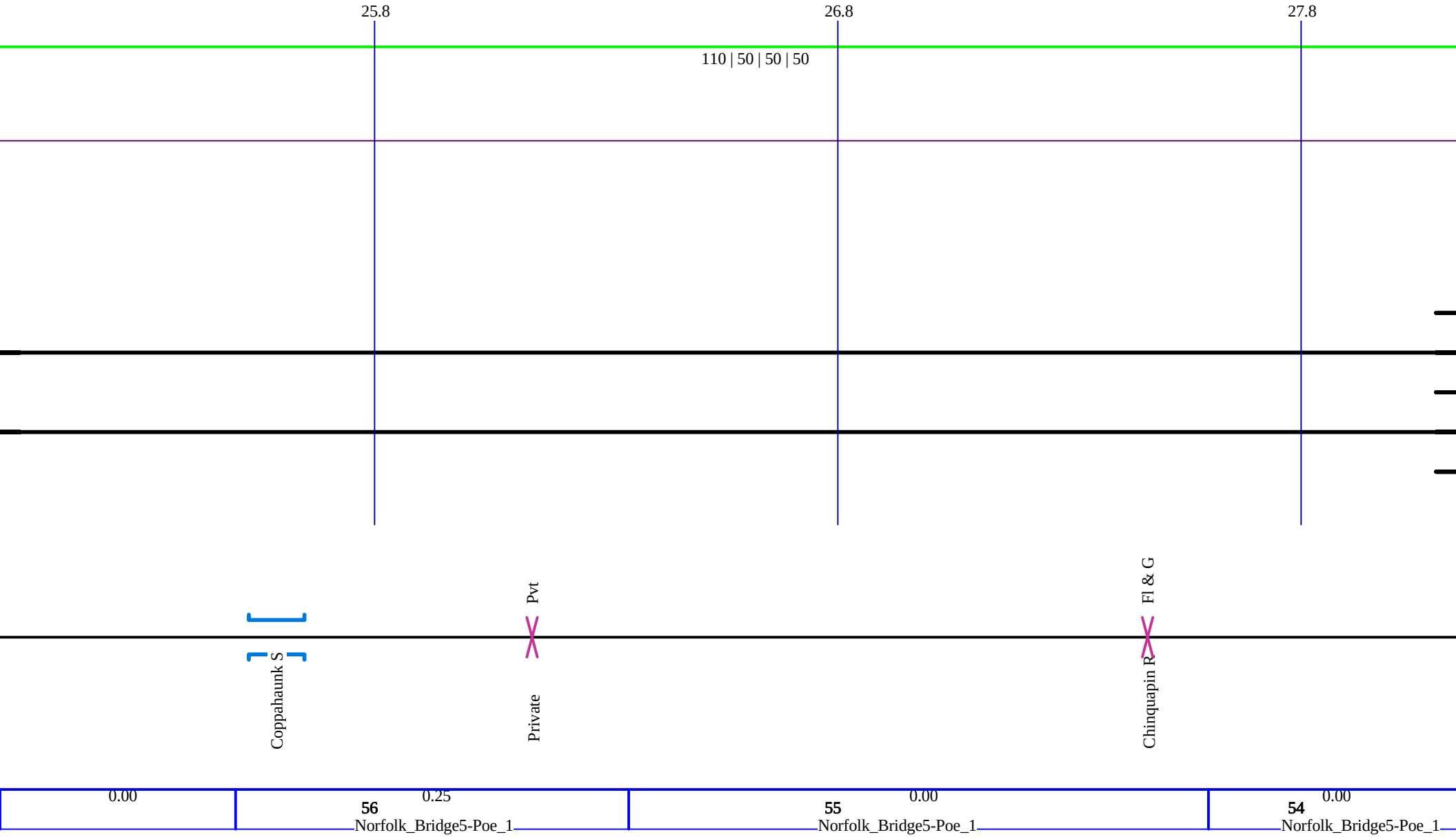
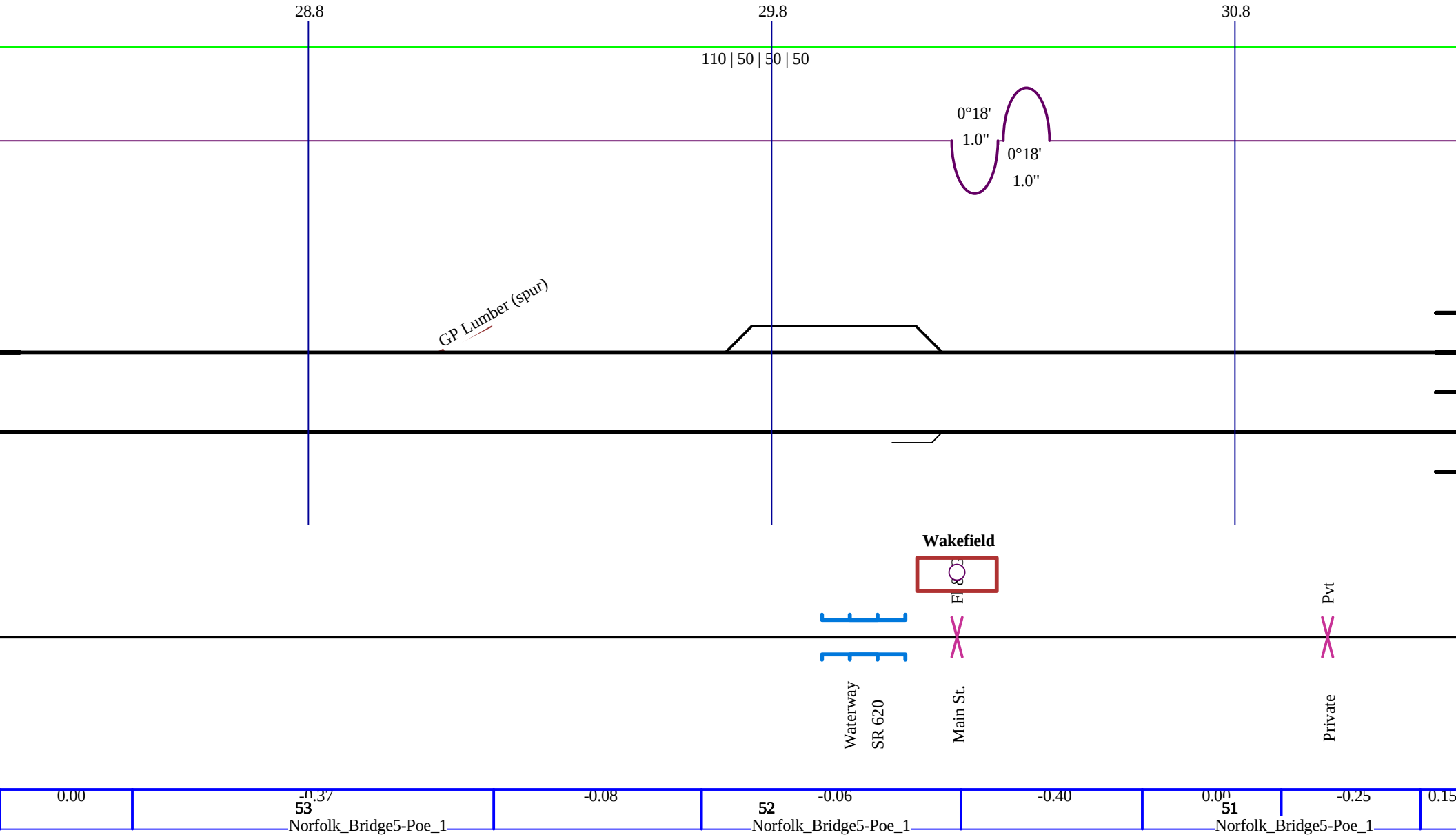
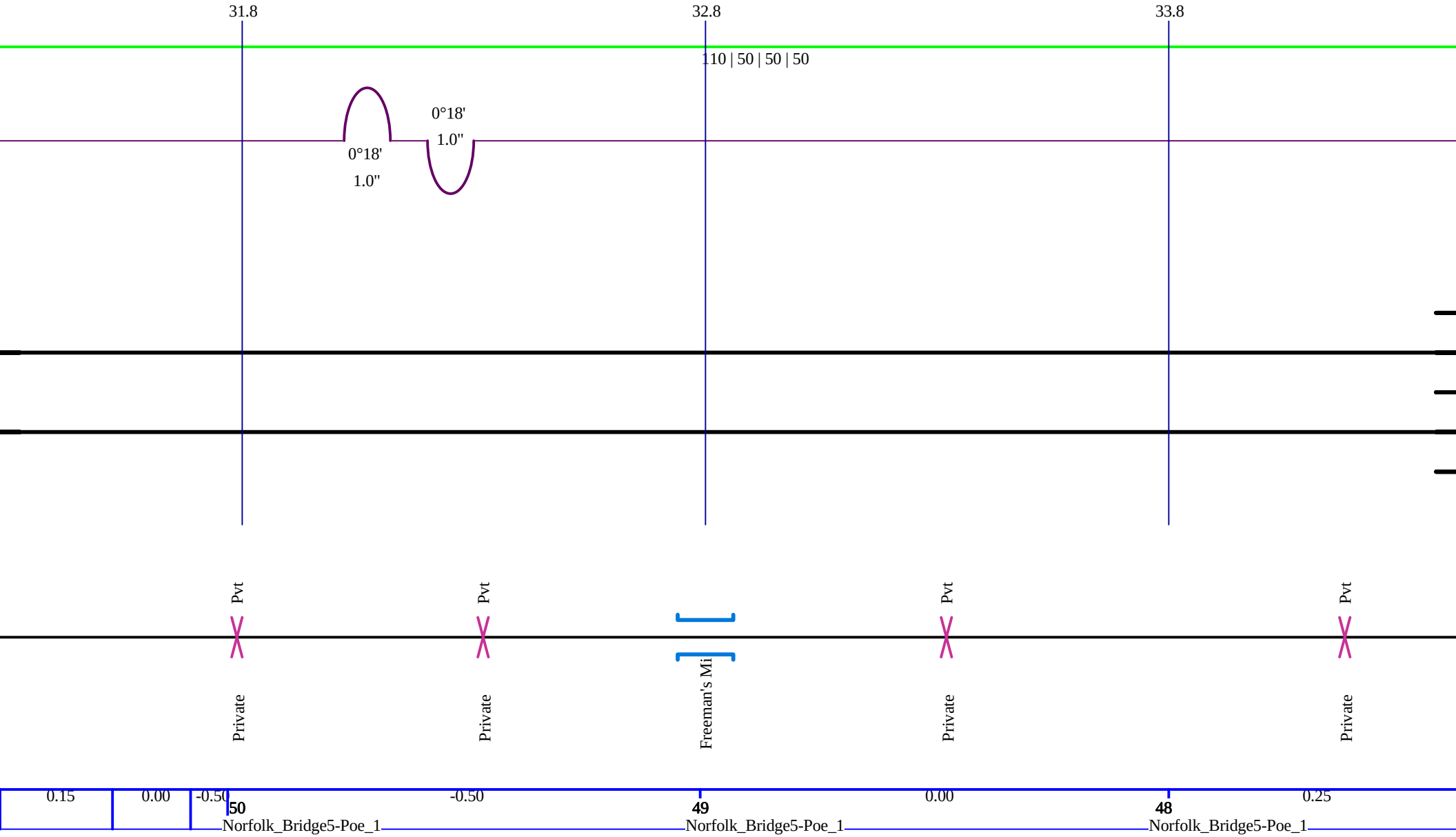
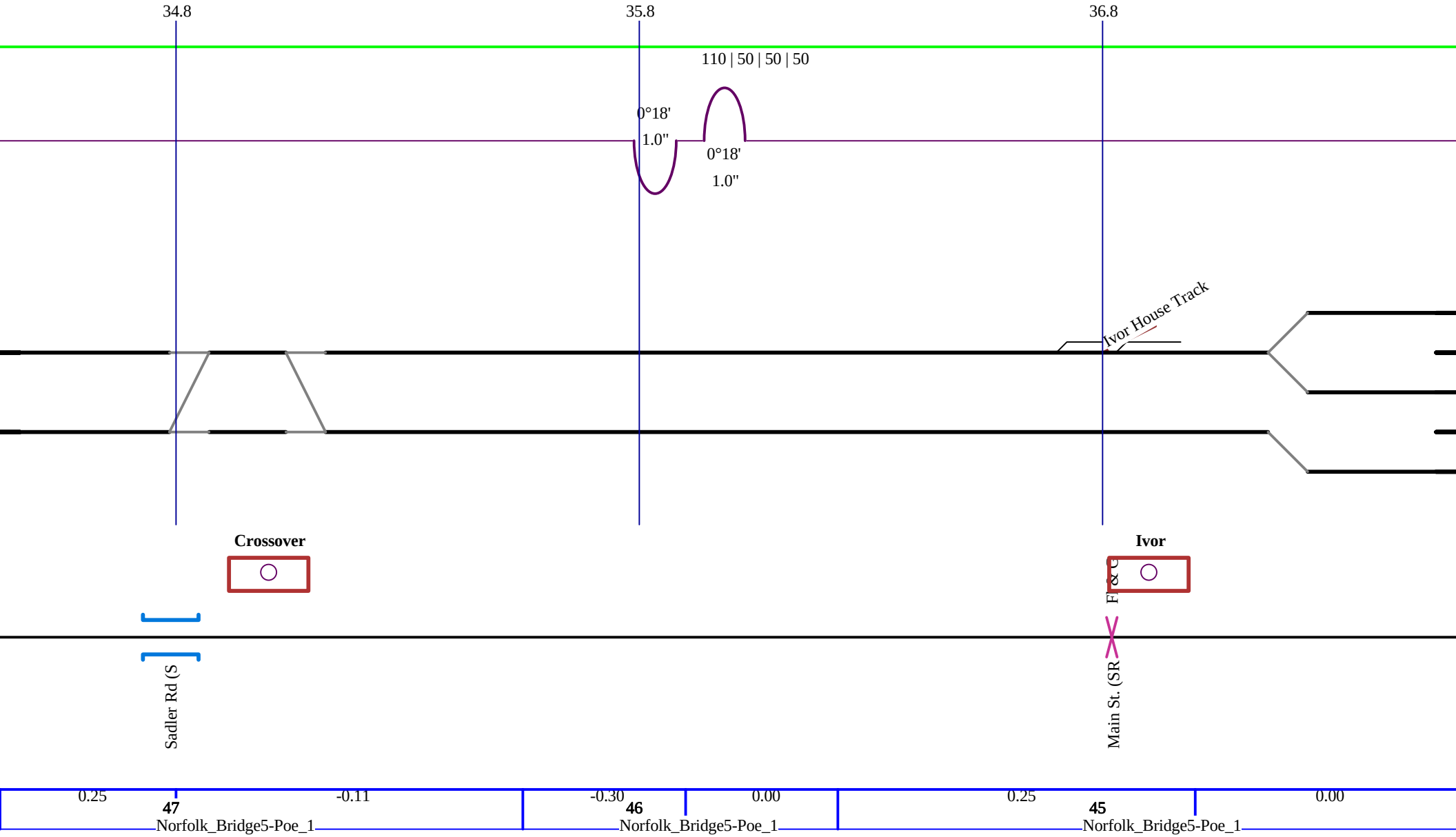
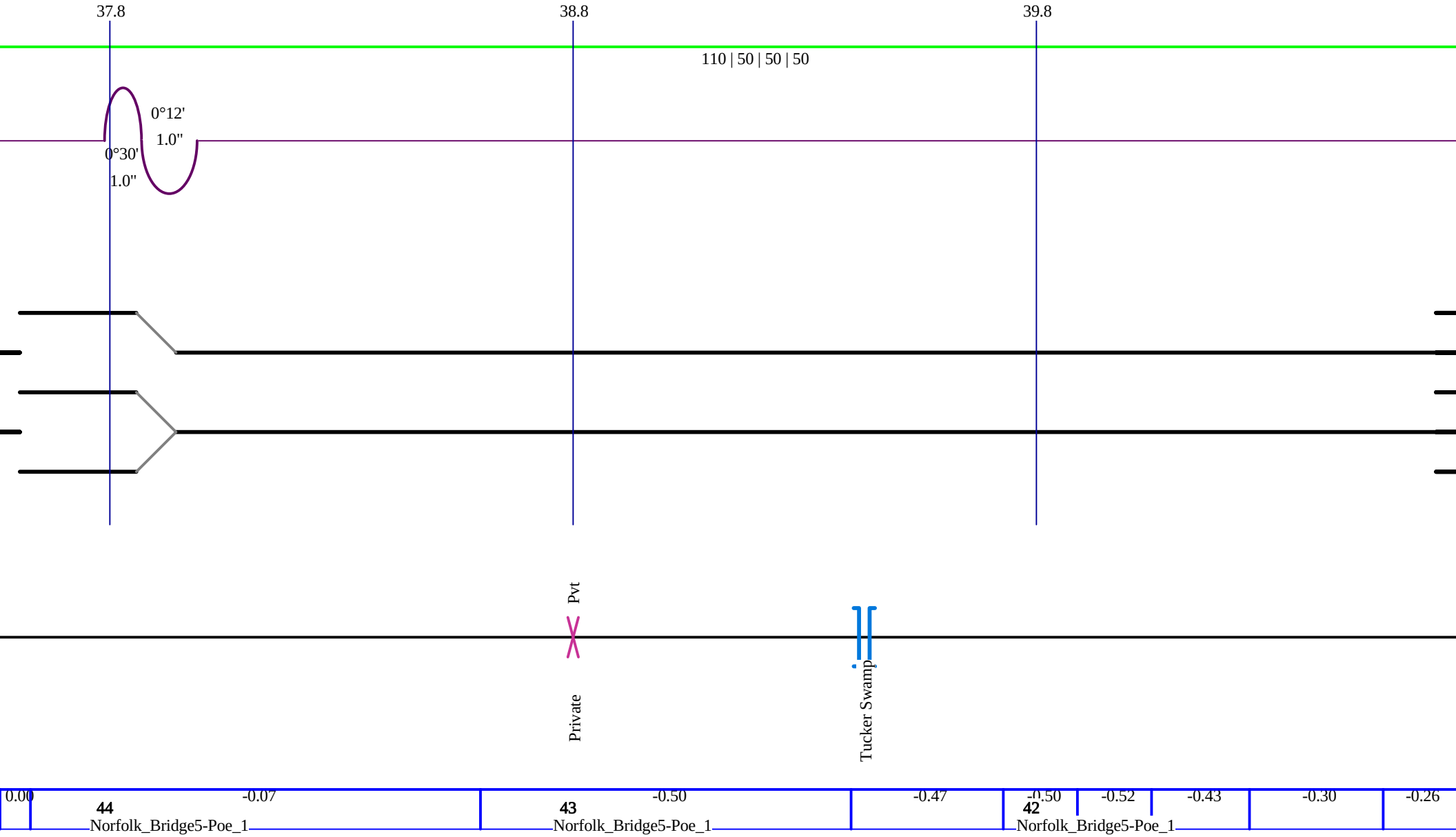
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5

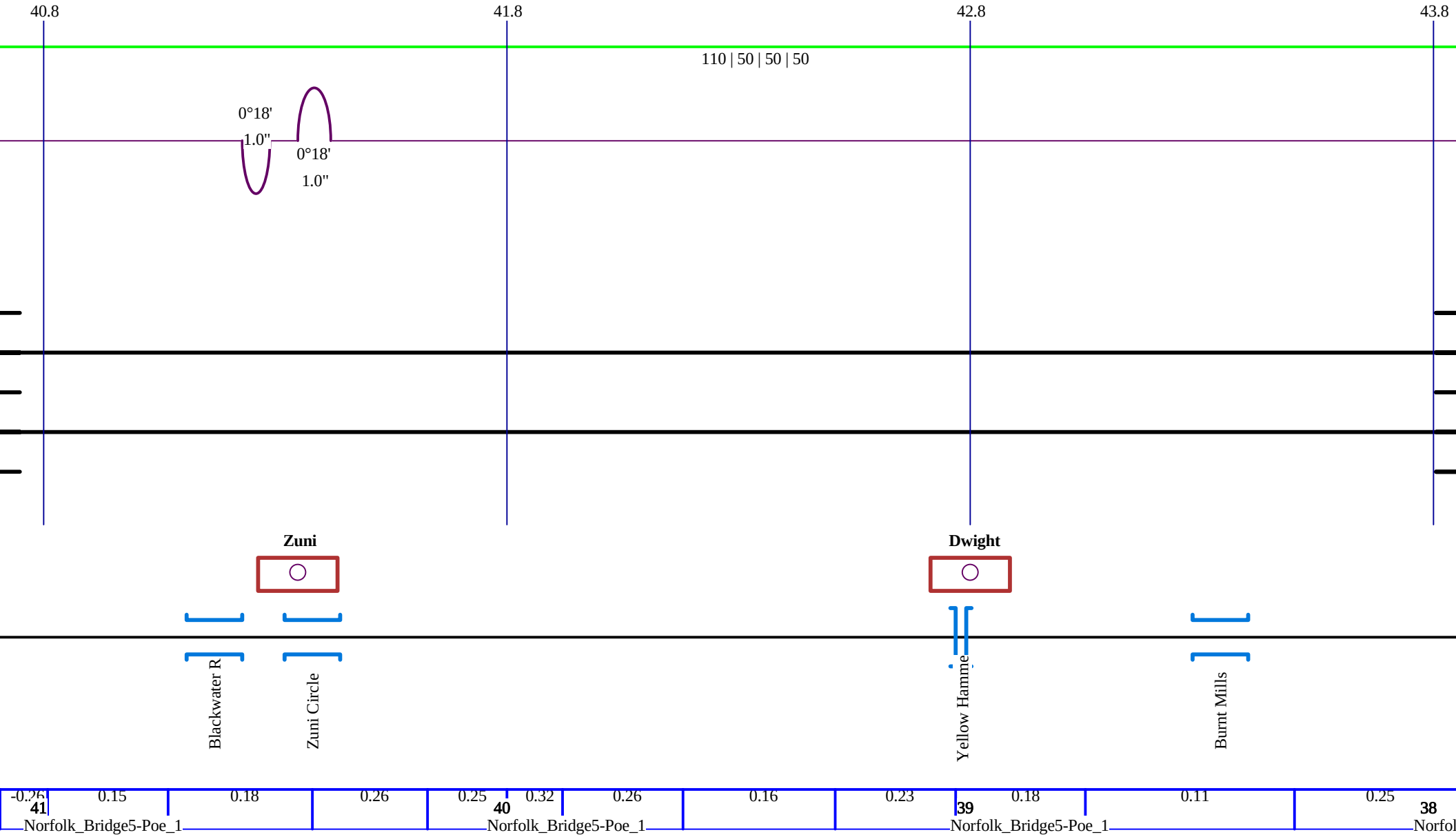

25.8
26.8
27.8
110 | 50 | 50 | 50
Coppahaunk S
Pvt
Private
Fl & G
Chinquapin R
0.00
56
0.25
Norfolk_Bridge5-Poe_1
55
0.00
Norfolk_Bridge5-Poe_1
54
0.00
Norfolk_Bridge5-Poe_1

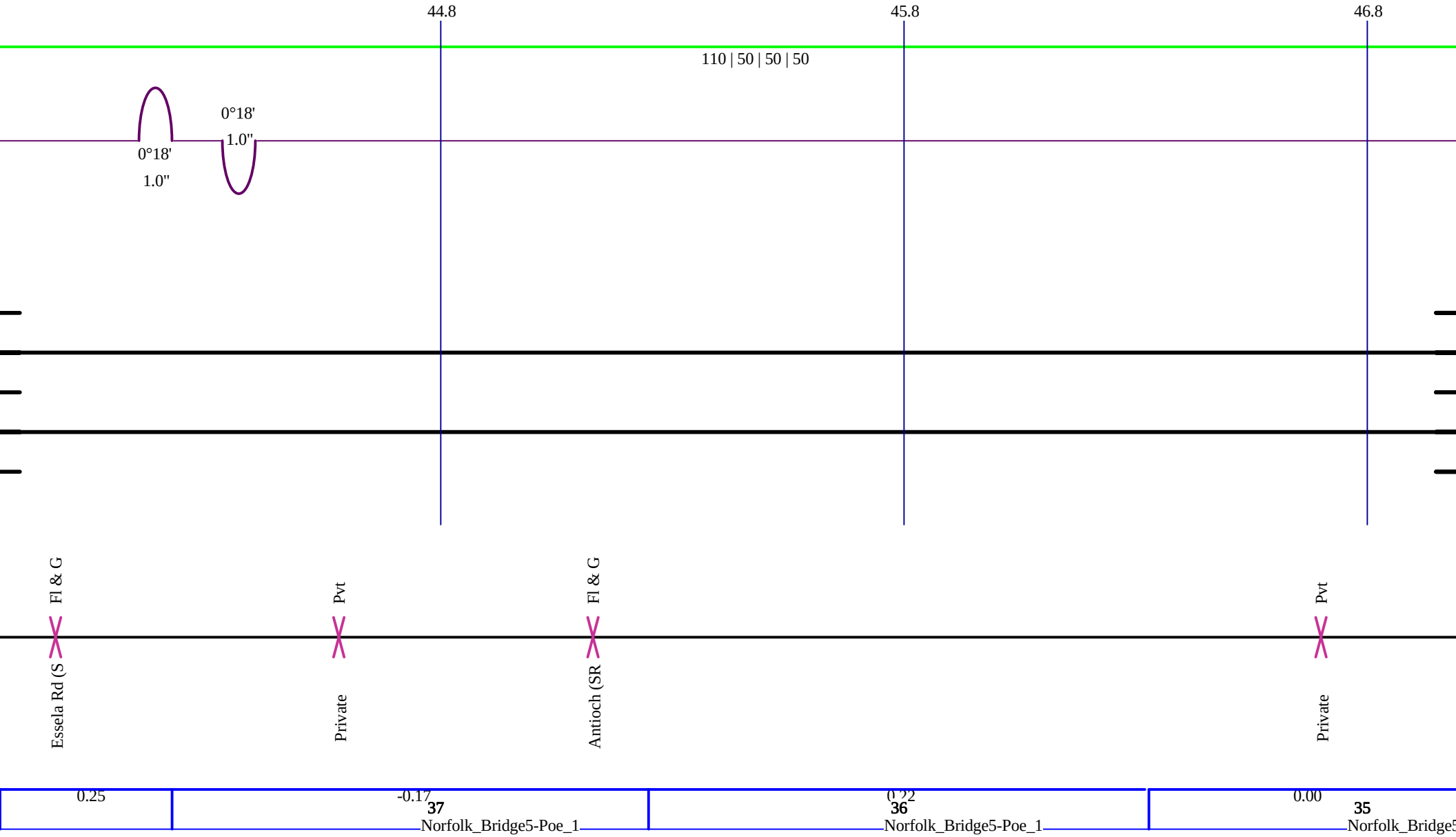

28.8
29.8
30.8
110 | 50 | 50 | 50
0°18'
1.0"
0°18'
1.0"
GP Lumber (spur)
Wakefield
Waterway
SR 620
Main St.
Private
0.00
-0.37
-0.08
-0.06
-0.40
0.00
-0.25
0.15
53
Norfolk_Bridge5-Poe_1
52
Norfolk_Bridge5-Poe_1
51
Norfolk_Bridge5-Poe_1

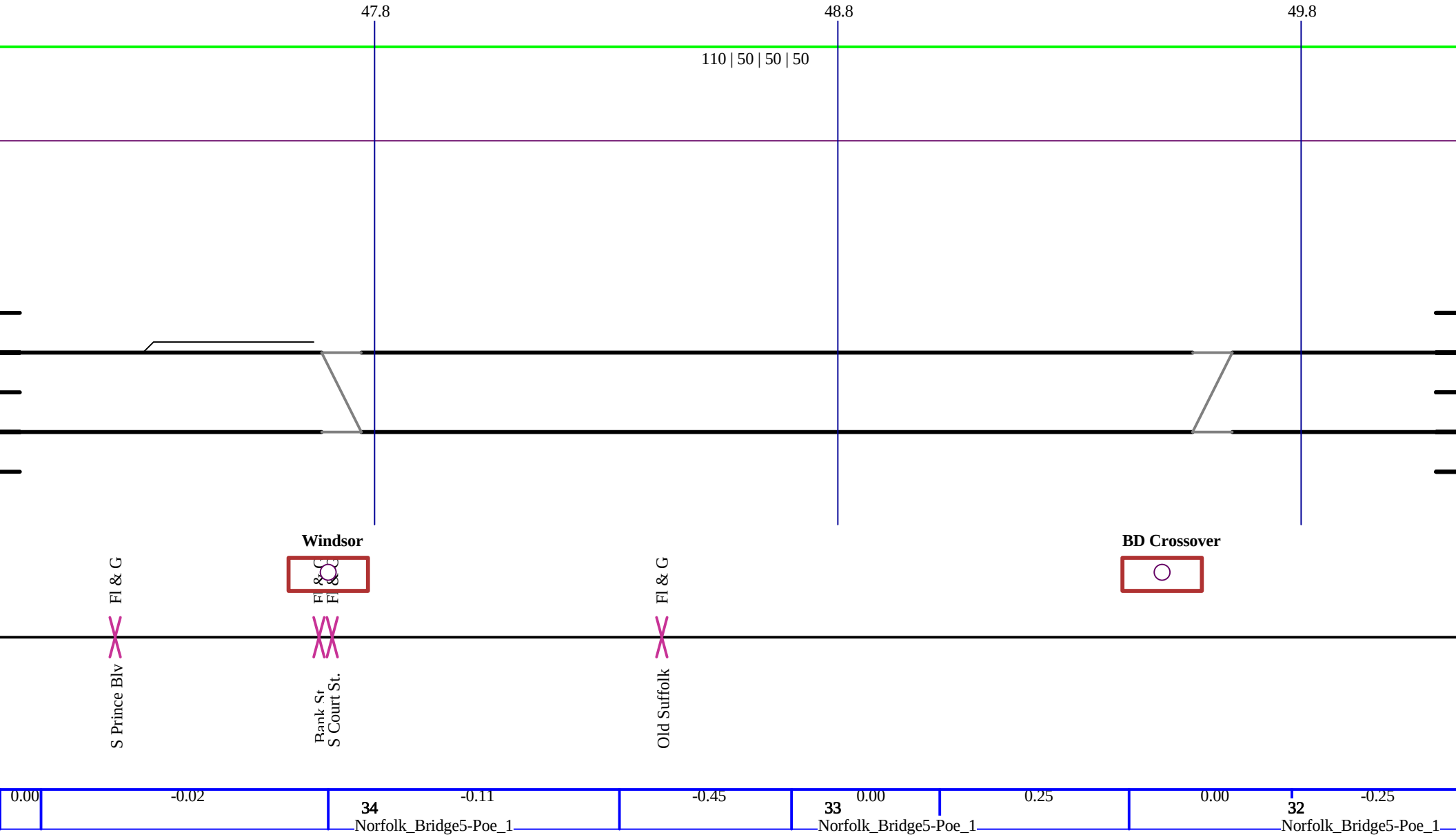

31.8
32.8
33.8
110 | 50 | 50 | 50
0°18'
1.0"
0°18'
1.0"
Pvt
Pvt
Pvt
Pvt
Private
Private
Freeman's Mi
Private
Private
0.15
0.00
-0.50
-0.50
0.00
0.25
50
49
48
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1

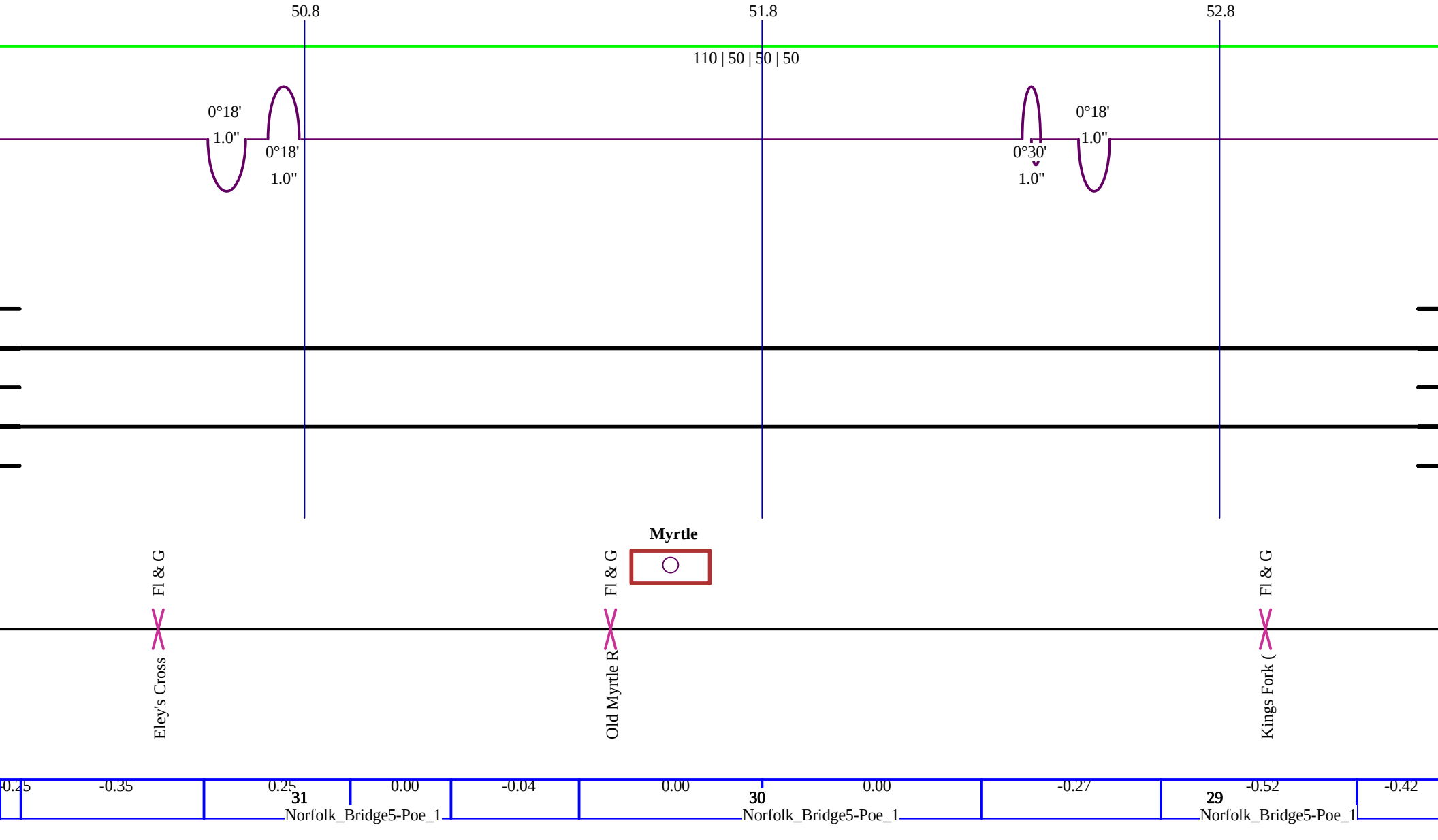

34.8
35.8
36.8
110 | 50 | 50 | 50
0°18'
1.0"
0°18'
1.0"
Ivor House Track
Crossover
Ivor
Sadler Rd (S
Main St. (SR
0.25
47
-0.11
-0.30
46
0.00
0.25
45
0.00
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1

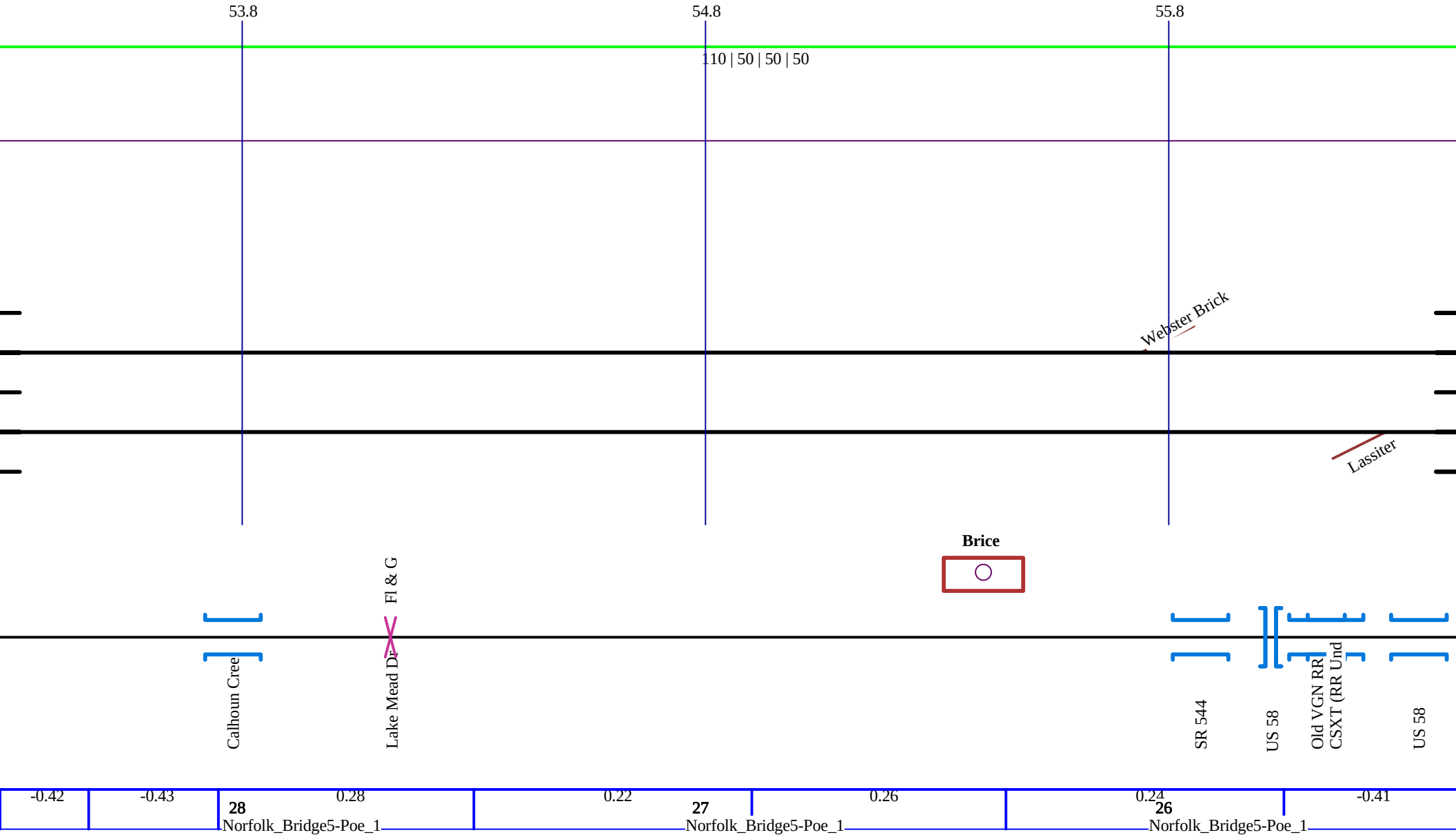

37.8
38.8
39.8
110 | 50 | 50 | 50
0°12'
1.0"
0°30'
1.0"
Pvt
Private
Tucker Swamp
0.00
-0.07
-0.50
-0.47
-0.50
-0.52
-0.43
-0.30
-0.26
44
Norfolk_Bridge5-Poe_1
43
Norfolk_Bridge5-Poe_1
42
Norfolk_Bridge5-Poe_1

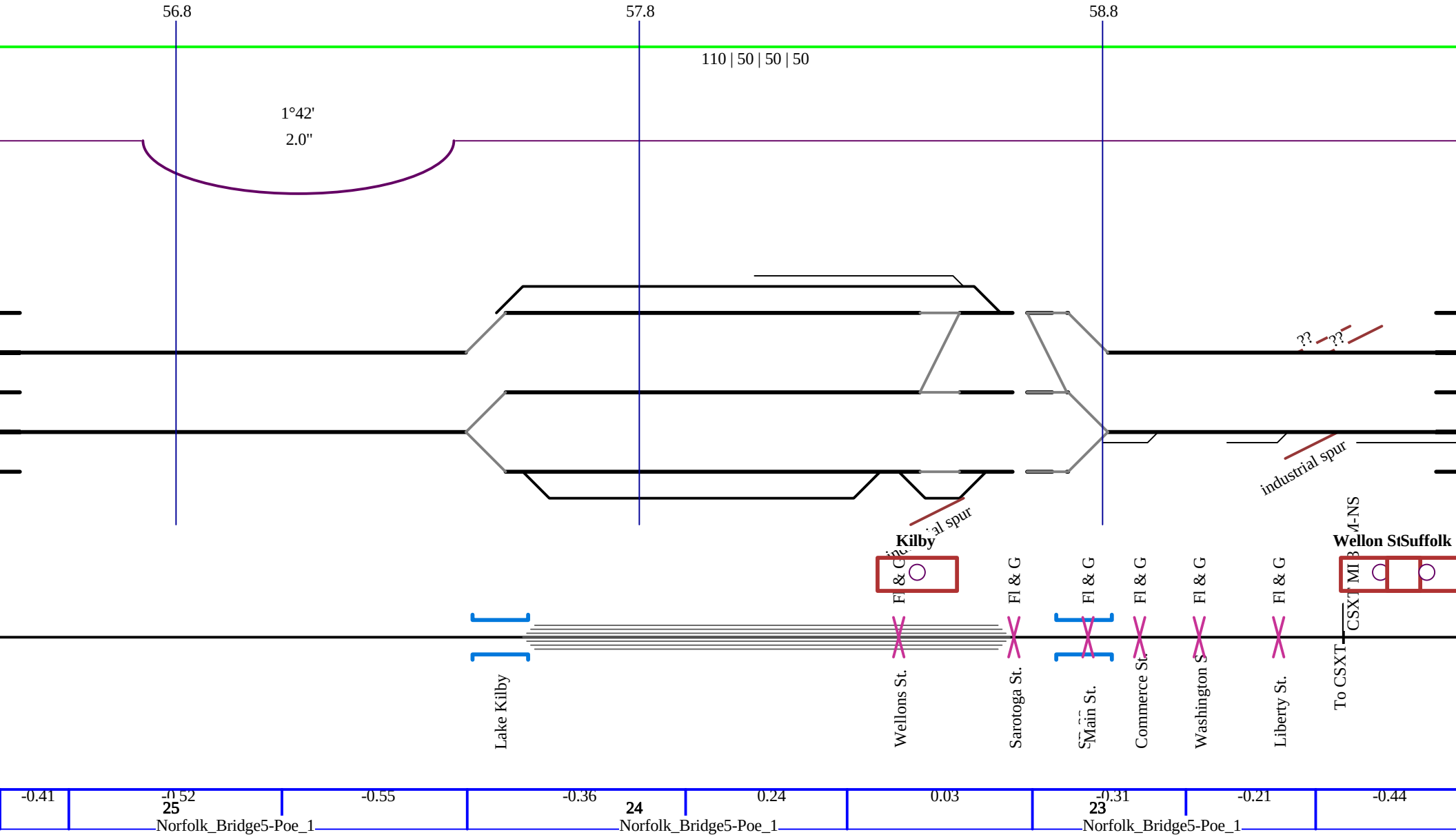

40.8
41.8
42.8
43.8
110 | 50 | 50 | 50
0°18'
1.0"
0°18'
1.0"
Zuni
Dwight
Blackwater R
Zuni Circle
Yellow Hamme
Burnt Mills
-0.26
0.15
0.18
0.26
0.25
0.32
0.26
0.16
0.23
0.18
0.11
0.25
41
40
39
38
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1
Norfol

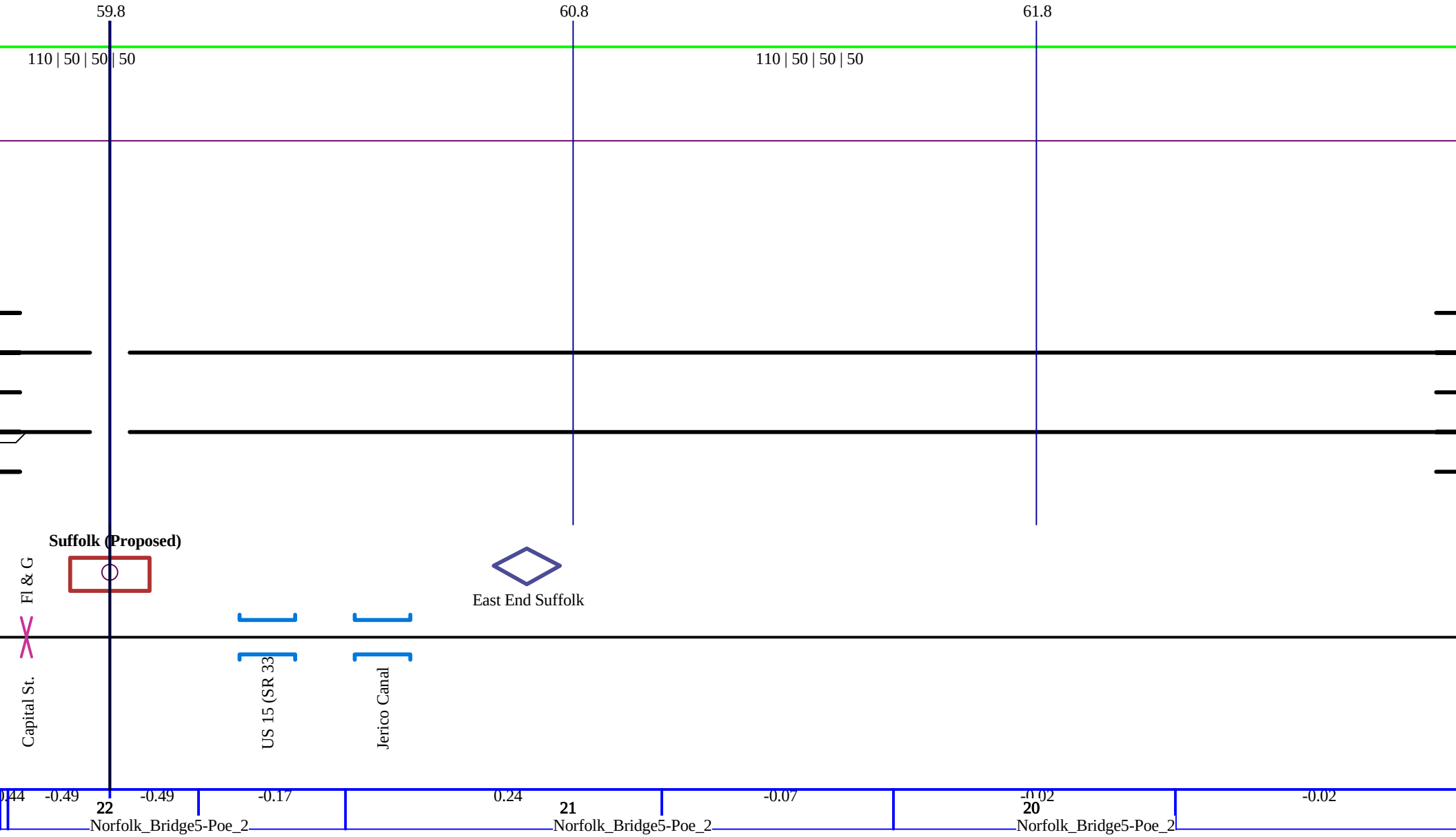

44.8
45.8
46.8
110 | 50 | 50 | 50
0°18'
1.0"
0°18'
1.0"
Fl & G
Pvt
Fl & G
Pvt
Essela Rd (S
Private
Antioch (SR
Private
0.25
-0.17
0.22
0.00
37
Norfolk_Bridge5-Poe_1
36
Norfolk_Bridge5-Poe_1
35
Norfolk_Bridge5

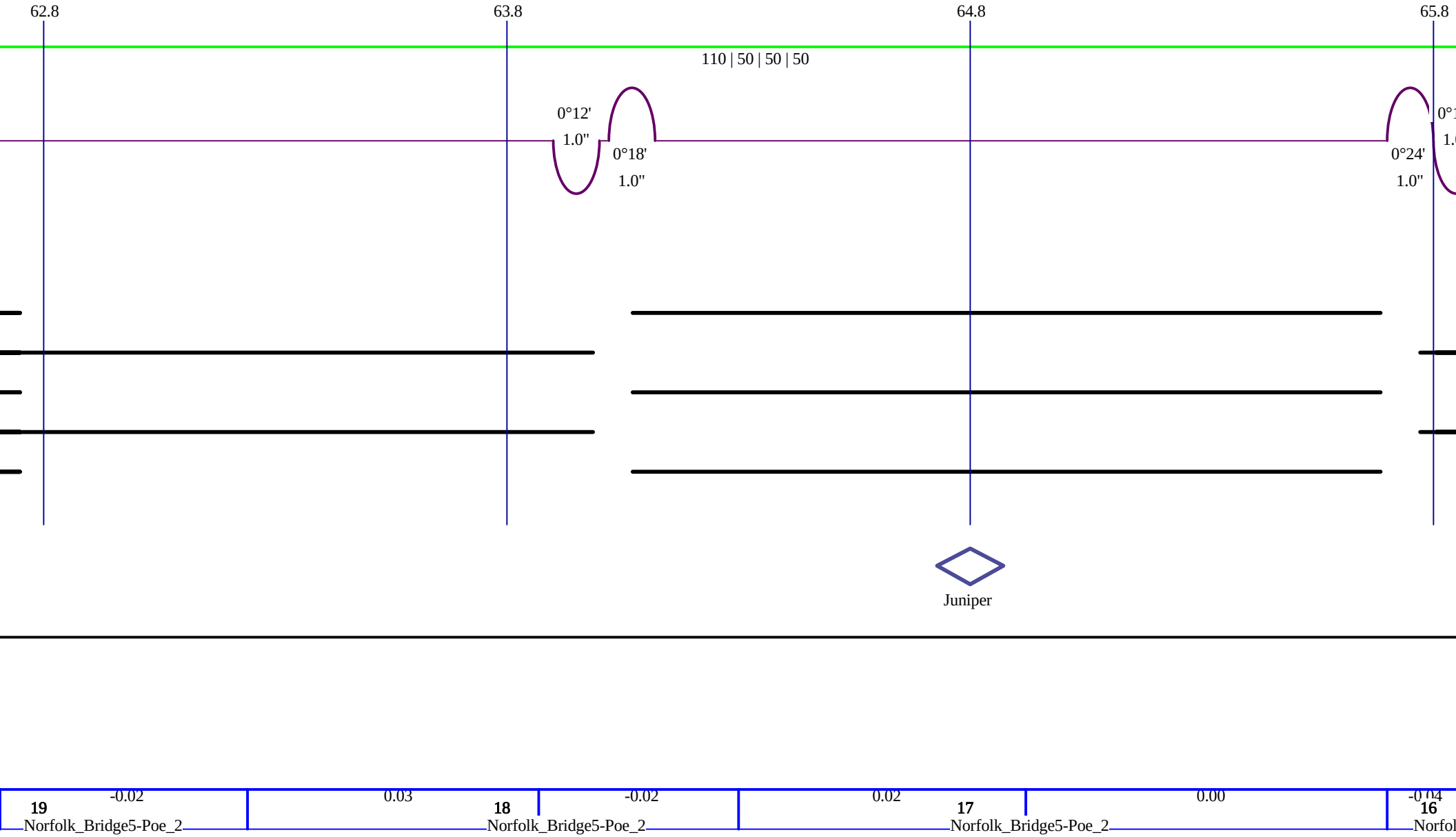

47.8
48.8
49.8
110 | 50 | 50 | 50
Windsor
BD Crossover
Fl & G
Fl & G
Fl & G
S Prince Blv
Bank St
S Court St.
Old Suffolk
0.00
-0.02
34
-0.11
Norfolk_Bridge5-Poe_1
-0.45
0.00
33
0.25
Norfolk_Bridge5-Poe_1
0.00
32
-0.25
Norfolk_Bridge5-Poe_1


50.8
51.8
52.8
110 | 50 | 50 | 50
0°18'
1.0"
0°18'
1.0"
0°30'
1.0"
0°18'
1.0"
Myrtle
Fl & G
Fl & G
Fl & G
Eley's Cross
Old Myrtle R
Kings Fork (
-0.25
-0.35
0.25
0.00
-0.04
0.00
0.00
-0.27
-0.52
-0.42
31
Norfolk_Bridge5-Poe_1
30
Norfolk_Bridge5-Poe_1
29
Norfolk_Bridge5-Poe_1

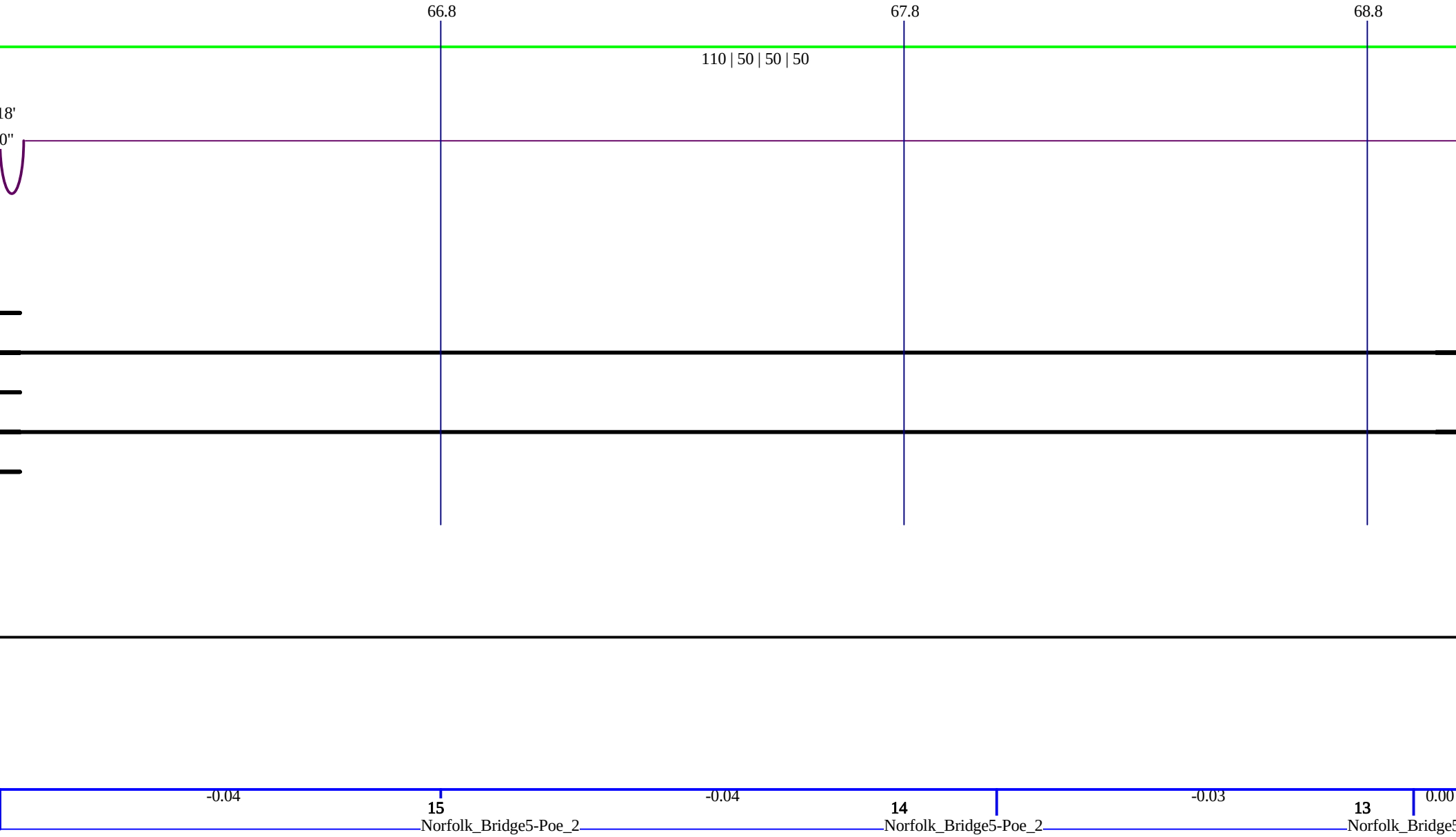

53.8
54.8
55.8
110 | 50 | 50 | 50
Webster Brick
Lassiter
Brice
Fl & G
Calhoun Cree
Lake Mead Dr
SR 544
US 58
Old VGN RR
CSXT (RR Und
US 58
-0.42
-0.43
28
0.28
0.22
27
0.26
0.24
26
-0.41
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1
Norfolk_Bridge5-Poe_1

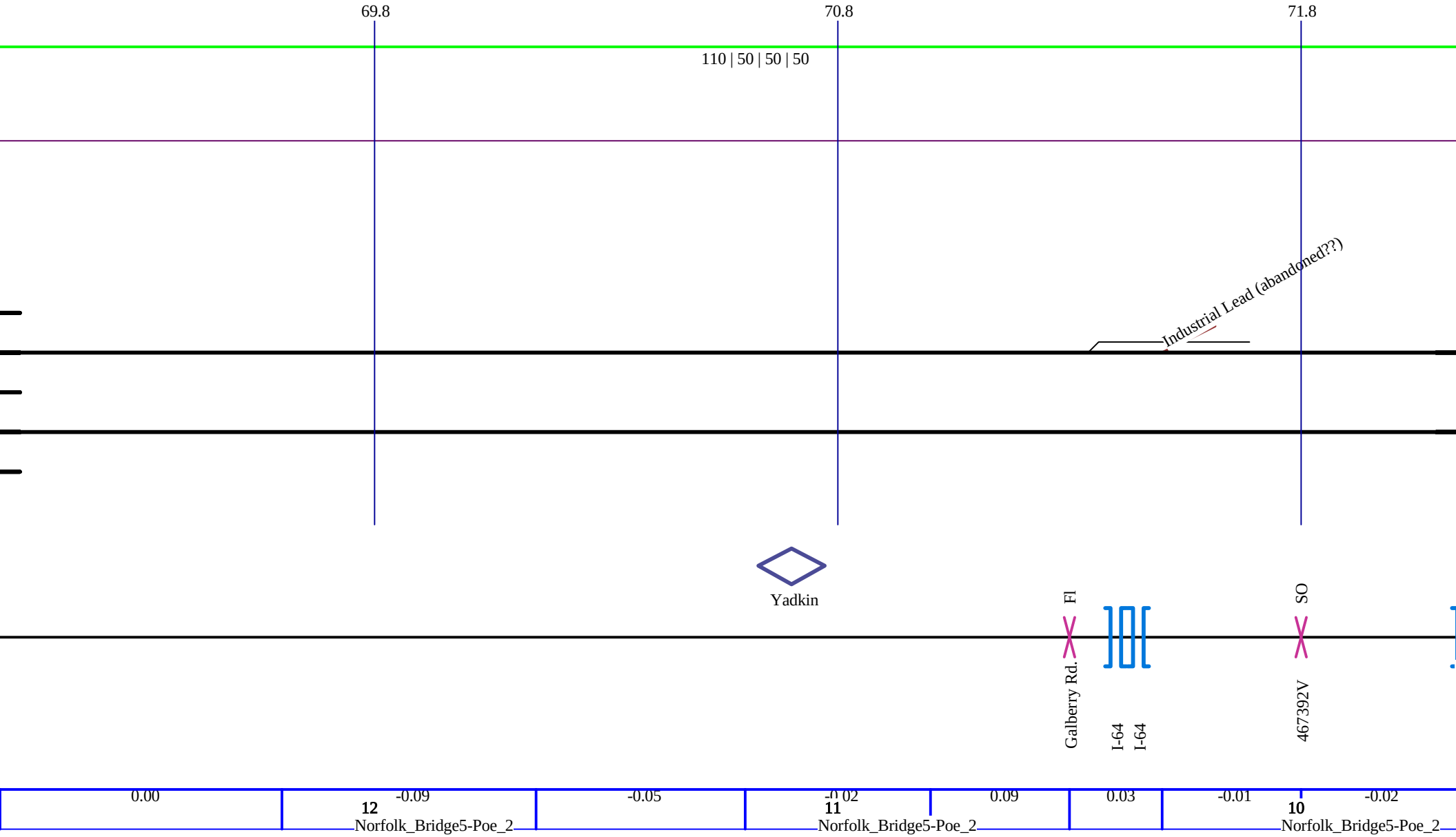

56.8
57.8
58.8
110 | 50 | 50 | 50
1°42'
2.0"
??
??
industrial spur
Kilby
Wellon St
Suffolk
CSXT
MP 3
N-NS
Fl & G
Fl & G
Fl & G
Fl & G
Fl & G
Fl & G
To CSXT
Lake Kilby
Wellons St.
Sarotoga St.
Main St.
Commerce St.
Washington St.
Liberty St.
-0.41
-0.52
-0.55
-0.36
0.24
0.03
-0.31
-0.21
-0.44
25
Norfolk_Bridge5-Poe_1
24
Norfolk_Bridge5-Poe_1
23
Norfolk_Bridge5-Poe_1

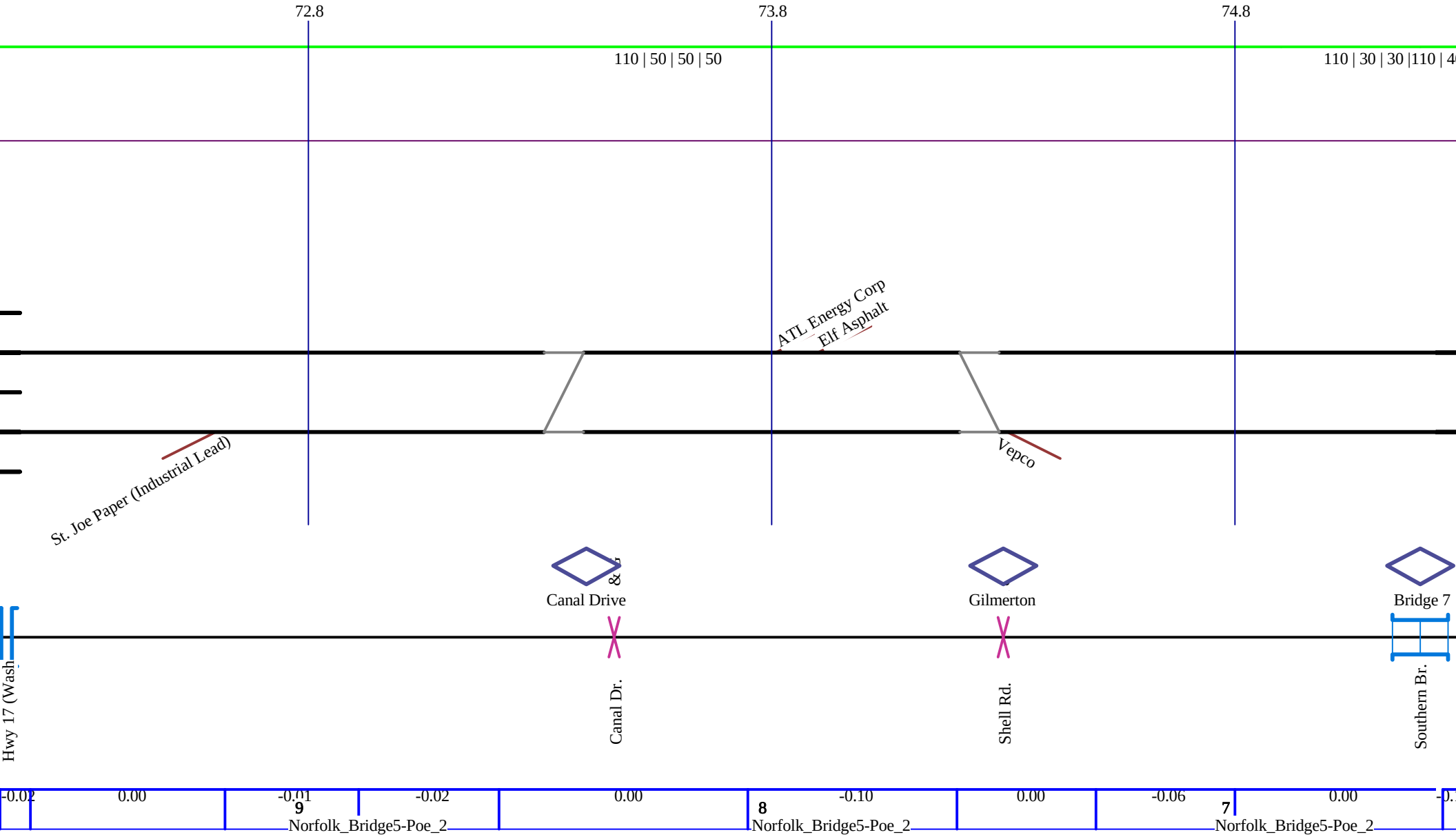

59.8
60.8
61.8
110 | 50 | 50 | 50
110 | 50 | 50 | 50
Suffolk (Proposed)
East End Suffolk
Fl & G
Capital St.
US 15 (SR 33
Jerico Canal
-0.49
-0.49
-0.17
0.24
-0.07
-0.02
-0.02
22
21
20
Norfolk_Bridge5-Poe_2
Norfolk_Bridge5-Poe_2
Norfolk_Bridge5-Poe_2

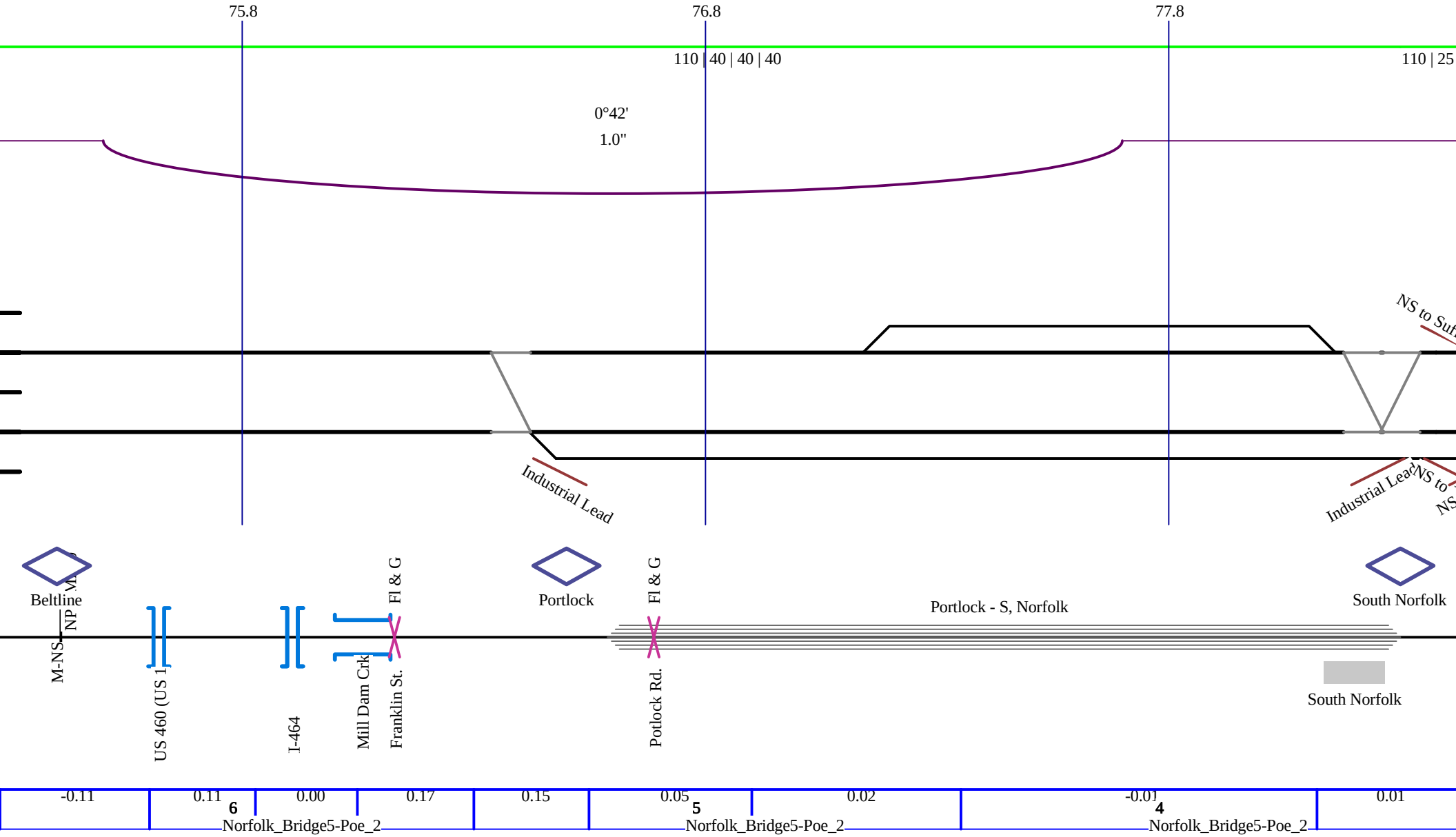

62.8
63.8
64.8
65.8
110 | 50 | 50 | 50
0°12'
1.0"
0°18'
1.0"
0°24'
1.0"
Juniper

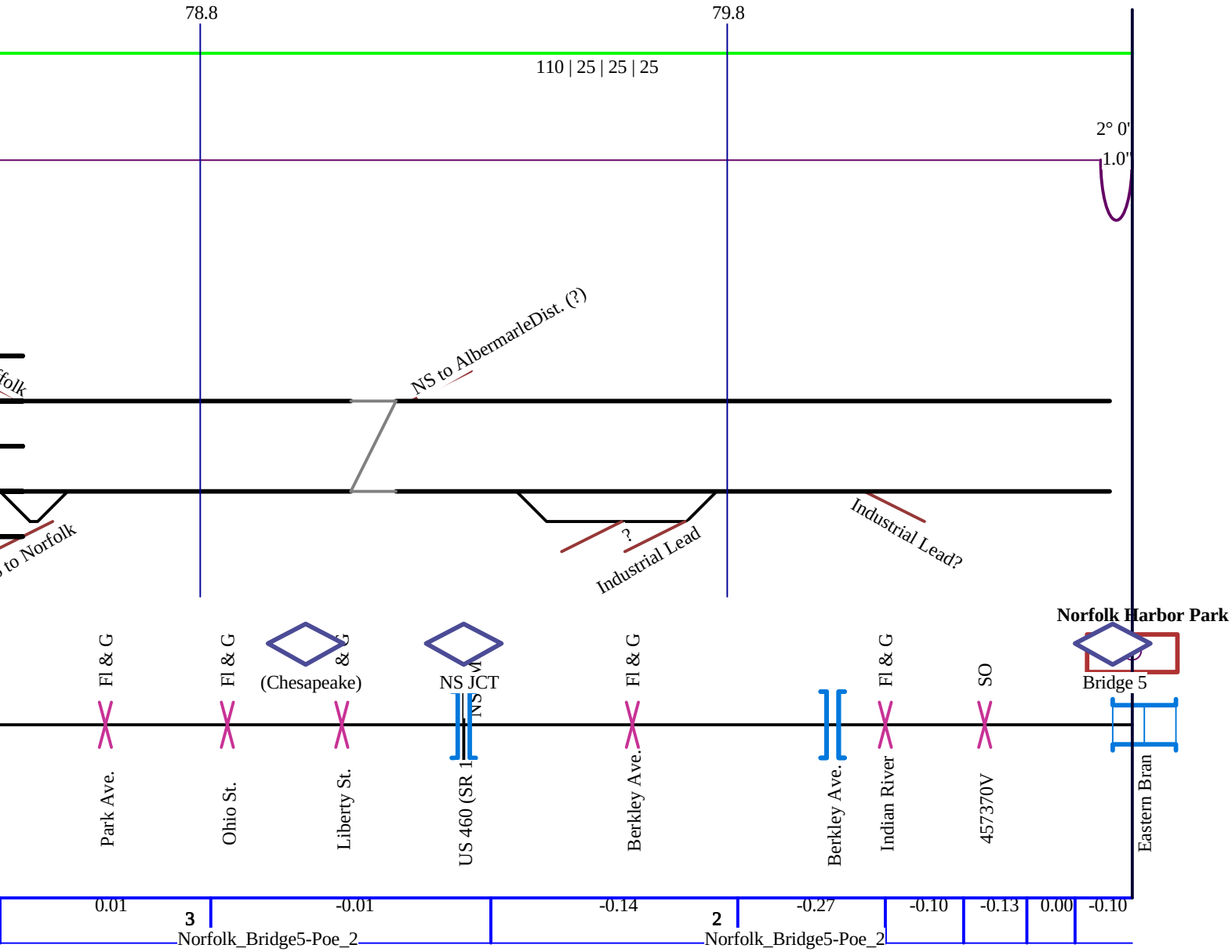
-0.02
0.03
-0.02
0.02
0.00
19
18
17
16
Norfolk_Bridge5-Poe_2
Norfolk_Bridge5-Poe_2
Norfolk_Bridge5-Poe_2
Norfol


66.8
67.8
68.8
110 | 50 | 50 | 50
18'
0"
-0.04
-0.04
-0.03
0.00
15
Norfolk_Bridge5-Poe_2
14
Norfolk_Bridge5-Poe_2
13
Norfolk_Bridge5


69.8
70.8
71.8
110 | 50 | 50 | 50
Industrial Lead (abandoned??)
Yadkin
Fl
SO
Galberry Rd.
I-64
I-64
467392V
0.00
-0.09
-0.05
-0.02
0.09
0.03
-0.01
-0.02
12
11
10
Norfolk_Bridge5-Poe_2
Norfolk_Bridge5-Poe_2
Norfolk_Bridge5-Poe_2


72.8
73.8
74.8
110 | 50 | 50 | 50
110 | 30 | 30 |110 | 4
ATL Energy Corp
Elf Asphalt
St. Joe Paper (Industrial Lead)
Vepco
Canal Drive
Gilmerton
Bridge 7
Hwy 17 (Wash
Canal Dr.
Shell Rd.
Southern Br.
-0.02
0.00
-0.01
-0.02
0.00
-0.10
0.00
-0.06
0.00
9
Norfolk_Bridge5-Poe_2
8
Norfolk_Bridge5-Poe_2
7
Norfolk_Bridge5-Poe_2


75.8
76.8
77.8
110 | 40 | 40 | 40
110 | 25
0°42'
1.0"
Industrial Lead
Industrial Lead
Beltline
M-NS
NP
US 460 (US 1
I-464
Mill Dam Crk
Fl & G
Franklin St.
Portlock
Fl & G
Potlock Rd.
Portlock - S, Norfolk
South Norfolk
South Norfolk
-0.11
0.11
0.00
0.17
0.15
0.05
0.02
-0.01
0.01
6
Norfolk_Bridge5-Poe_2
5
Norfolk_Bridge5-Poe_2
4
Norfolk_Bridge5-Poe_2

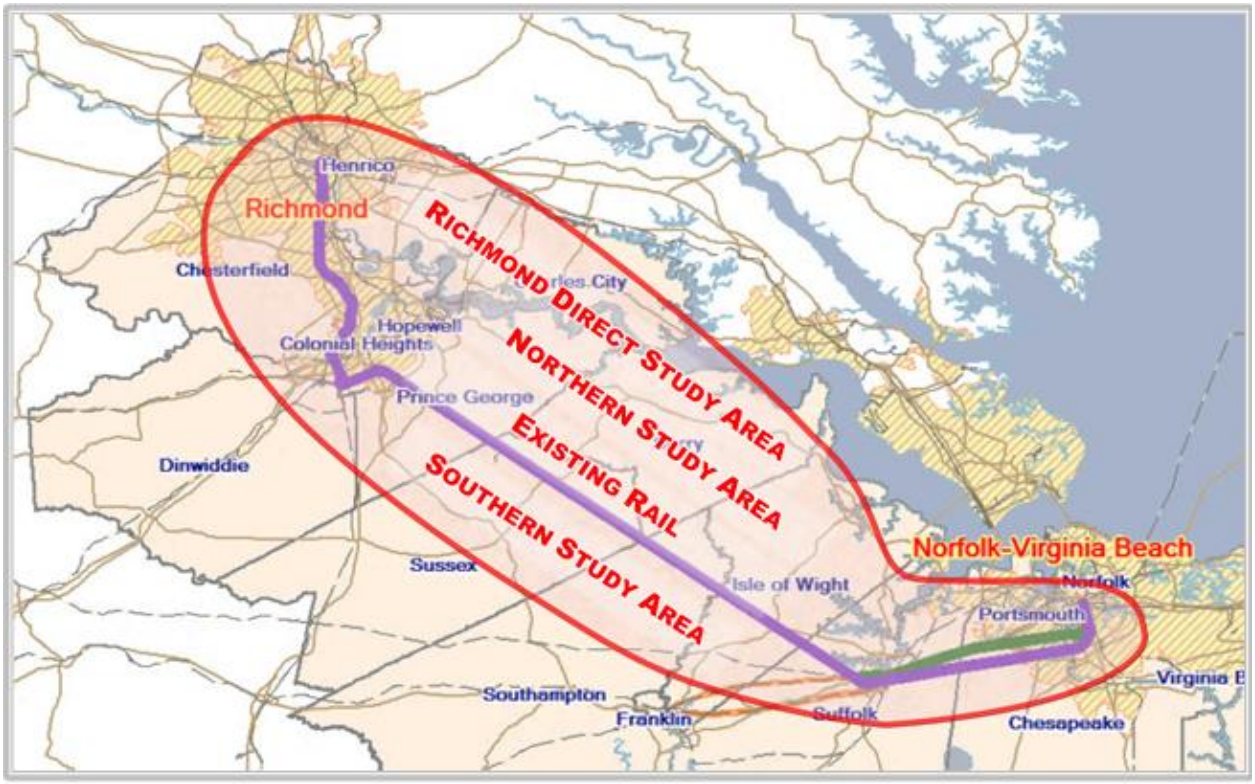

78.8
79.8
110 | 25 | 25 | 25
2° 0'
1.0"
NS to AlbermarleDist. (?)
to Norfolk
?
Industrial Lead
Industrial Lead?
Norfolk Harbor Park
Fl & G
Fl & G
(Chesapeake)
NS JCT
Fl & G
Fl & G
SO
Bridge 5
Park Ave.
Ohio St.
Liberty St.
US 460 (SR 1
Berkley Ave.
Berkley Ave.
Indian River
457370V
Eastern Bran
0.01
-0.01
-0.14
-0.27
-0.10
-0.13
0.00
-0.10
3
Norfolk_Bridge5-Poe_2
2
Norfolk_Bridge5-Poe_2

APPENDIX D: ENVIRONMENTAL SCAN (UPDATED)

1. OVERVIEW

This appendix is an environmental scan/analysis update to Chapter 5 of the "*Hampton Roads Passenger Rail Study Data Collection – Phase 2A Norfolk – Hampton Roads Corridor*" report that was produced by TEMS, Inc. in March of 2013. This includes environmental updates to the full corridor study area going from Richmond to Norfolk. All data collection figures have been updated for the expanded study area shown in Exhibit D-1. (Note: The previous report only reflected environmental data collection results and exhibits for the Petersburg to Norfolk segment of the corridor.) Specifically, this appendix updates environmental scans for cultural resources, conservation lands, historic resources, ecology (wetlands, wildlife and recreational resources), environmental justice, and agricultural land and soil values; and, the conclusion section has been updated accordingly. This appendix also includes brief summaries of data collection results for the following environmental impacts: hazardous materials, air quality, noise and vibration, utilities, and public health and safety. In addition, this environmental update includes discussion and data exhibits on natural land networks and biodiversity found within the Richmond to Norfolk study area; and in particular, discusses the usage of the Virginia Natural Landscape Assessment (VaNLA) tool for identifying and prioritizing linked natural habitats based on their ecological value to the region overall.

Exhibit D-1: Environmental Study Area



*Alignment will not be determined until the Tier II Environmental Process is complete.

2. CULTURAL RESOURCES

As part of the overall environmental scan of the Richmond to Norfolk study area, potential impacts to cultural resources were identified. Cultural resources include parks, wildlife refuges, heritage preserves, archaeology resources, historical resources, federal lands, etc. The Department of Virginia Conservation and Recreation (DCR) provides information on parks, wildlife refuge, heritage preserves, federal lands, etc. The National Park Service (NPS) provides information on historic resources. In the next sections of this report, conservation lands and historic resources for the environmental study area from Richmond to Norfolk are discussed.

2.1 CONSERVATION LANDS

Conservation lands in Virginia are classified into four categories: forest, parks, wildlife, and other. Exhibit D-2 shows conservation lands located within the Richmond to Norfolk environmental study area for these four types. The 'forest' category includes national and state forests; 'parks' include national and state parks; 'wildlife' includes refuge and management areas; and 'other' conservation lands mainly include land holdings and area preserves. For the environmental study area from Richmond to Norfolk, the total acreage of conservation land is approximately 222,168 acres, of which the National Wildlife Refuge is approximately 95,969 acres (Exhibit D-3). In the next phase of the study, these conservation lands would need to be taken into consideration when choosing the alternatives. For any greenfield sections of the corridor between Richmond and Suffolk, care should be taken to avoid impacts with conservation lands by having the new rail alignment take a path around such sites.

Exhibit D-2: DCR Conservation Lands in the Richmond to Norfolk Environmental Study Area

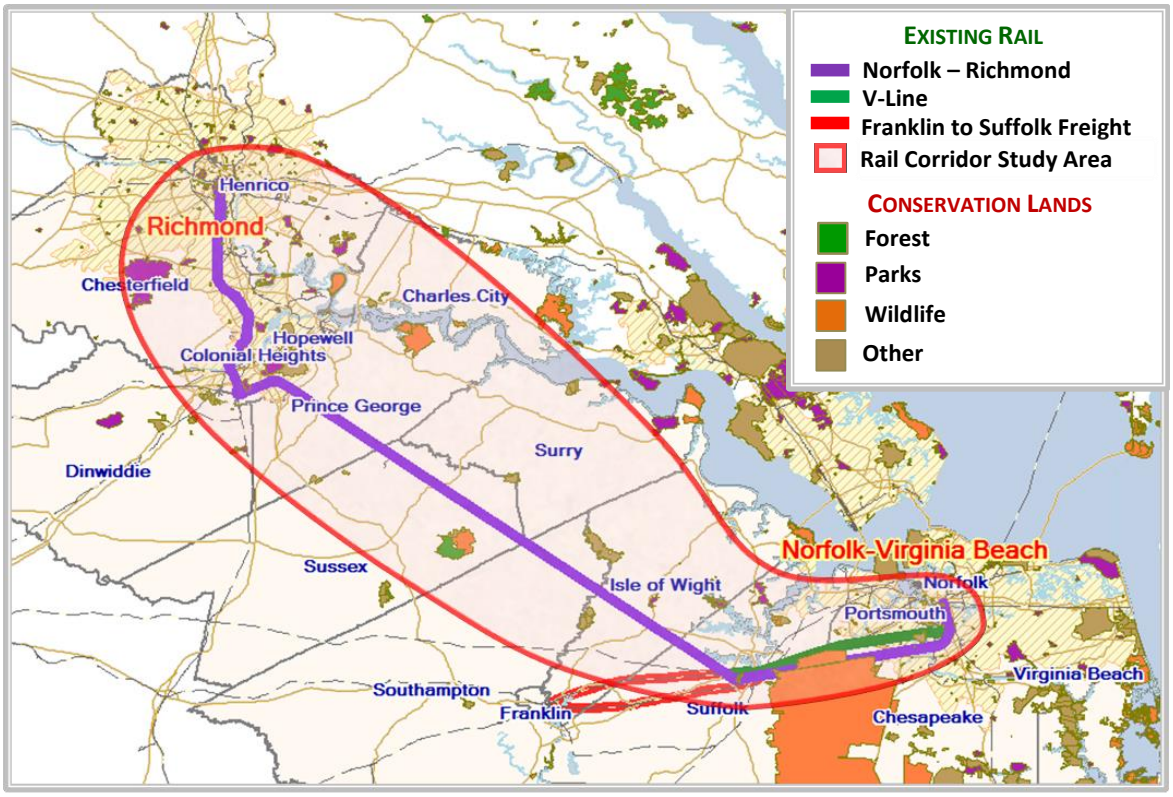


Exhibit D-3: DCR Conservation Lands Total Acres in the Petersburg/Richmond to Norfolk Environmental Study Area[1]

Main Category	Sub-Category	Acres (Approx.)
Forest		2,414
	State Forest	2,200
	State Forestry Center	214
Other		63,318
	Locality Land Holding	2,300
	Military Installation	32,011
	Non-Profit Fee Simple Holding	3,221
	State Natural Area Preserve	13,861
	TNC Land Holding	354
	TNC Preserve	11,571
Park		43,550
	Local Park	20,261
	State Park	16,457
	National Park	6,832
Wildlife		112,886
	National Wildlife Refuge	95,169
	State Wildlife Management Area	17,717
Total		222,168

2.2 HISTORIC RESOURCES

The National Park Service (NPS) U.S Department of the Interior[2] provides state-wide historic resources information. This includes providing data on protected historic sites such as Churches, Chapels, Monuments, Schools, Cemeteries, etc. Approximately 300 protected historical sites or resources fall within the environmental study area. Exhibit D-4 shows the approximate locations of these protected historical sites. As seen in the exhibit, the largest numbers of protected historical sites fall within the section of the corridor between Richmond and Petersburg. In areas where the rail alignment follows existing rail or highway 'right of ways', and where historical sites have already been avoided or mitigated, any conflicts with historical resources here should be minimal or non-existent. For greenfield sections of the corridor, care should be taken to avoid impacts with historical sites by having the new rail alignment bypass or take a path around such sites. Exhibit D-5 shows an example of a historical site within the environmental study area that must be avoided by the new alignment.

[1] This table was based the information provided in shapefile data provided by http://www.dcr.virginia.gov/
[2] http://nrhp.focus.nps.gov/natreg/docs/Download.html

Exhibit D-4: Historic Resources in the Richmond to Norfolk Environmental Study Area*

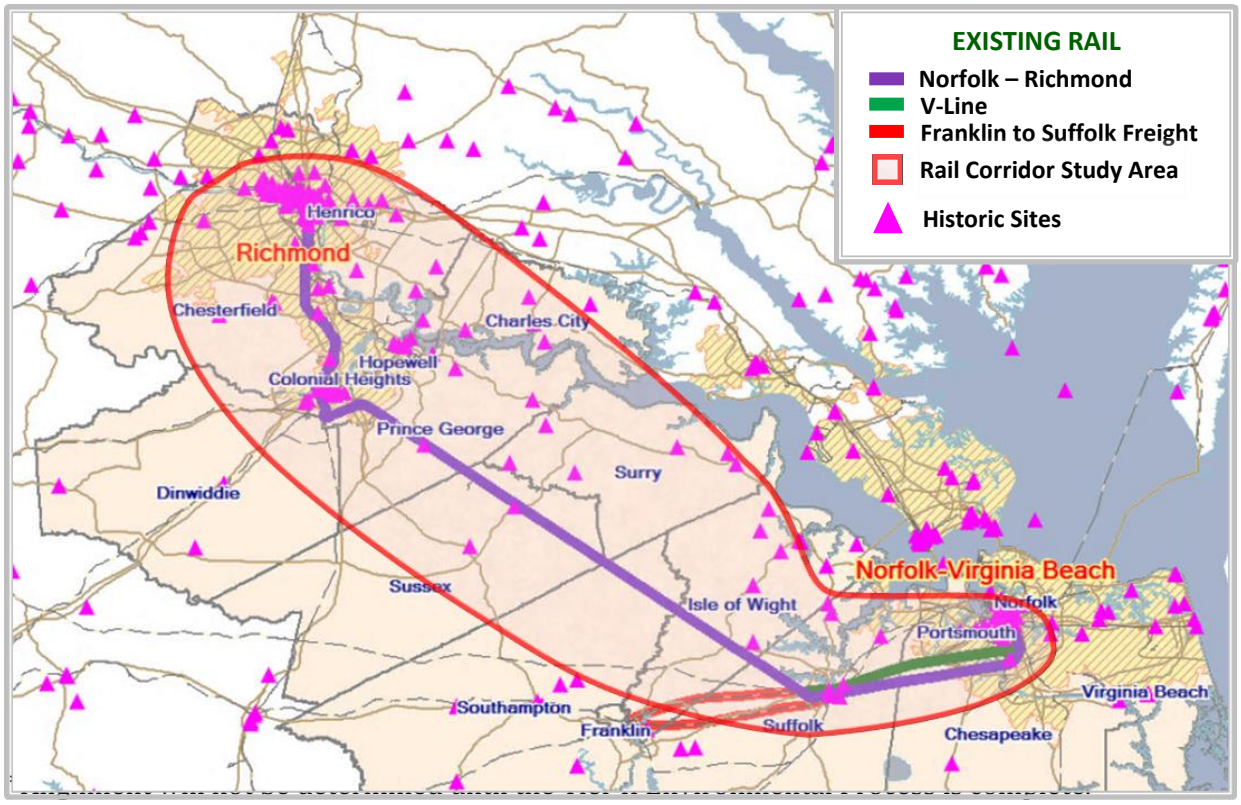


Exhibit D-5: Historic Site – Church in Walters, VA within the Environmental Study Area

3. ECOLOGY

A scanning of ecological resources was conducted as part of the overall environmental scan for the environmental study area. This ecological scan included identifying potential ecological impacts: wetlands, hydric soils, streams, waterways (US & State waters), federally protected species, state protected species, critical stream habitats, migratory bird habitats, floodplain encroachment/impacts, and coastal zone encroachments come under ecology. These ecology systems are discussed in the next subsections.

3.1 WETLANDS

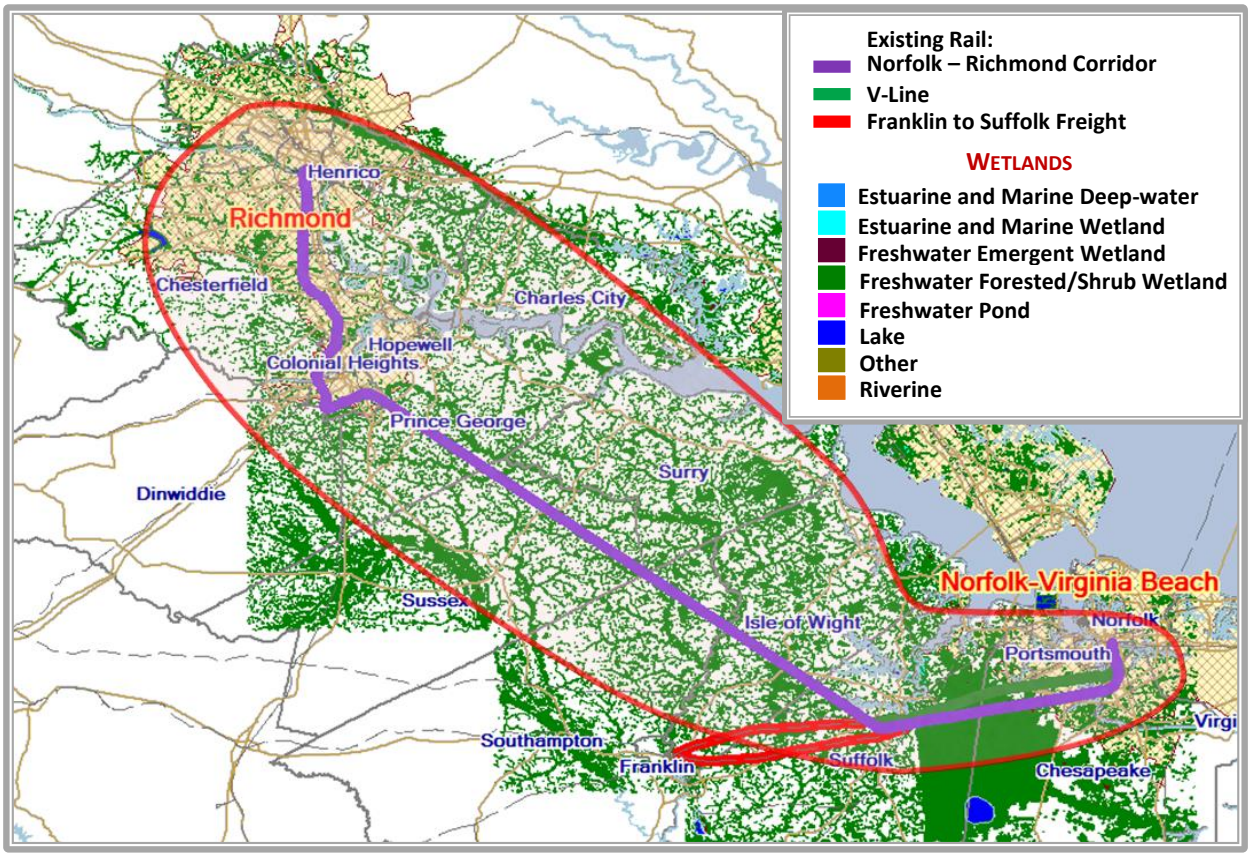
Wetlands are defined by the United States Fish and Wildlife Service (USFWS) as: "Land that has a predominance of hydric soils and that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances does support, hydrophytic vegetation adapted for saturated soil conditions."[3] Wetlands are one of the most important resources for the Virginia landscape; and, they are particularly critical in the tidal regions of the Chesapeake Bay where they support a variety of vegetation and wildlife that are vital to the entire region's ecosystem. The US Fish and Wildlife Service provides information on wetlands throughout the US. through its National Wetlands Inventory Program.[4] The inventory program classifies wetlands into the following types:

- Estuarine and Marine Deepwater
- Estuarine and marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Riverine and
- Other wetlands

Exhibit D-6 displays wetlands located in the Richmond to Norfolk study area. It can be seen that wetlands are a ubiquitous landscape feature across the whole study area and as such, are not completely avoidable. In this study, an attempt has been made to minimize wetland impacts in order to be in compliance with Executive Order 11990[5] for Protection of Wetlands. This has been done by shifting the alignment to avoid wetlands where possible, attempting to cross wetlands as near to a right angle as possible, and by bridging over all wetland areas that are in flood plains. Where wetland takes are deemed necessary, coordination with the U.S. Army Corps of Engineers is required to ensure that appropriate measures are used to mitigate any impacted wetlands, including replacing wetlands where necessary, at the required ratios.

[3] www.fws.gov/wetlands/nwi
[4] www.fws.gov/wetlands/nwi
[5] http://www.archives.gov/federal-register/codification/executive-order/11990.html

Exhibit D-6: Wetlands for the Petersburg to Norfolk Environmental Study Area



Within the environmental study area, there are notable 'Freshwater Forested/ Shrub' wetlands especially in the Dismal Swamp area which lies between Suffolk and Norfolk.

Some sample images of the wetland areas are shown in Exhibits D-7 to D-10. Exhibit D-7 shows a wetland along the existing tracks and Exhibit D-8 shows wetland along the abandoned "V" line corridor, just east of Suffolk and north of the Great Dismal swamp. Exhibits D-9 and D-10 show ponds within the environmental study area.

Exhibit D-7: Wetland along the Rail Track

Exhibit D-8: Abandoned Rail Bridge on "V" Line over a Wetland Area

Exhibit D-9: Bakers Pond in Disputanta, VA

Exhibit D-10: Bakers Pond in Disputanta, VA

Exhibit D-11 shows that the majority of wetlands for the Richmond to Norfolk study area are freshwater forested/shrub wetlands (311,500 acres approx.); and, a major portion of the area between Suffolk and Norfolk, is dense wetland area (as shown previously in Exhibit D-6). Depending on the area of coverage, many of these freshwater forested/shrub wetlands, if not bridged because they are in a flood plain, can be mitigated by filling or replacing at the required ratios specified by current regulations. It should be noted however that the proposed crossing of the Dismal Swamp east of Suffolk will be along a corridor of rail and highway right of way (Norfolk Southern "V"-Line, CSX Portsmouth Subdivision paralleling US-58) which has already been filled. No additional wetland takings affecting the Dismal Swamp have been identified by this preliminary scan for development of the rail infrastructure improvements. In a future phase of work, an effort needs to be made to minimize or avoid any wetland takings that may be associated with development of the Bowers Hill station.

Exhibit D-11: Wetland Total Area in the Environmental Study Area from Richmond to Norfolk

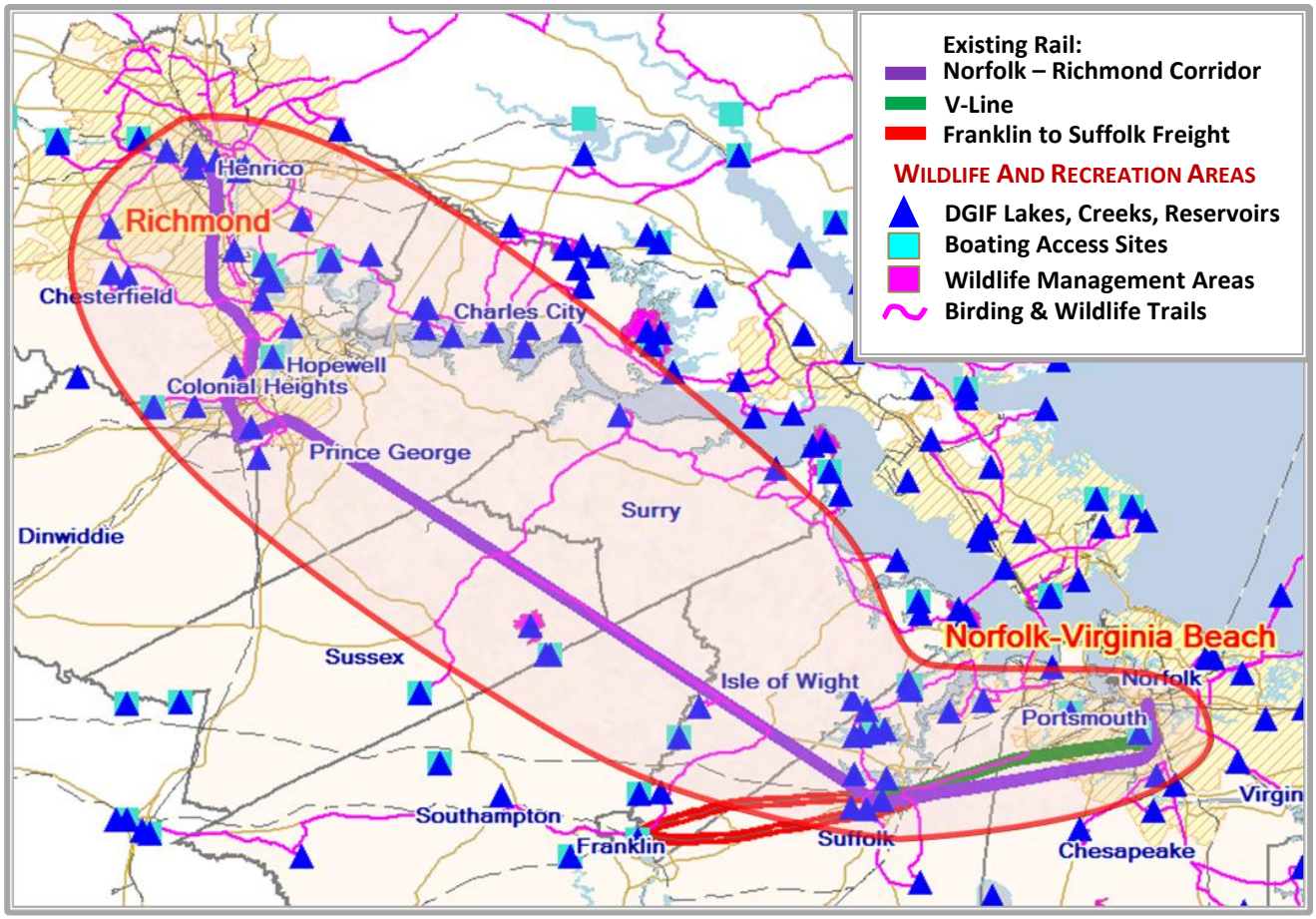
Wetland Types	Total Acres
Freshwater Forested/Shrub Wetland	311,537
Freshwater Emergent Wetland	19,257
Lake	17,547
Freshwater Pond	13,195
Estuarine and Marine Wetland	11,073
Riverine	3,174
Estuarine and Marine Deepwater	812.3
Other	254.2
TOTAL	376,850

The next highest levels of wetlands fall into the 'Freshwater Emergent Wetland' classification at approximately (19,257 acres) and "Lake" wetlands (17,547 acres); followed by freshwater ponds, estuarine and marine wetlands. Freshwater lakes, ponds, and riverine impacts can be minimized by constructing bridges at the required specifications rather than by filling, depending on the area of coverage.

3.2 Wildlife And Recreational Resources

The Virginia Department of Game and Inland Fisheries (DGIF)[6] provide data on Wildlife Management Areas (WMAs) and public fishing lakes. This data also includes information on lakes, creeks, swamps, reservoirs, fishing areas, inland navigable waters, boating sites, and bird trails and wildlife loops. The goal of DGIF's Wildlife Management Area Program is to maintain and enhance habitats that support game and nongame wildlife while providing opportunities for the public to hunt, fish, trap, and view wildlife. Other uses of WMAs may be allowed, as long as they do not interfere with these goals and uses. Exhibit D-12 shows wildlife and recreational resources located in the environmental study area from Richmond to Norfolk.

Exhibit: D-12: Wild Life Habitat in the Environmental Study Area* from Petersburg to Norfolk



[6] http://www.dgif.virginia.gov/wildlife/

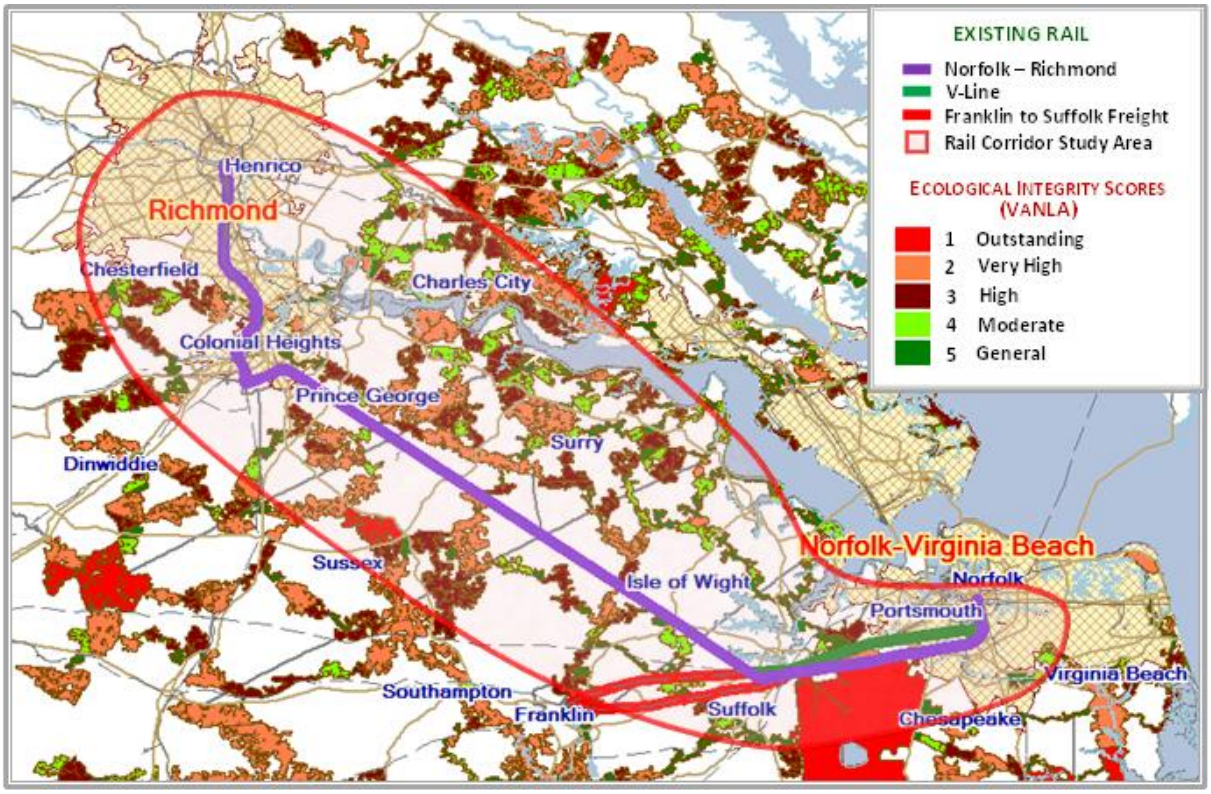
The prospective alignments considered for this preliminary study have avoided wildlife and recreational areas where possible. To the extent that endangered species locations have been identified in the relevant databases, these have been avoided also. In the next phase of the study, the U.S. Fish and Wildlife Service will need to be consulted to provide guidance, and assistance in addressing any impacts to endangered species or species habitat areas that may be identified in a future field survey of these resources.

4. PRESERVATION OF NATURAL LAND NETWORKS AND BIODIVERSITY

The Virginia Natural Landscape Assessment (VaNLA) is a landscape-scale GIS analysis[7] provided by the Virginia Department of Conservation and Recreation through its Virginia Natural Heritage Program (VNHP). It identifies, prioritizes and links natural habitats based on their overall ecological value in forming natural land networks connecting species habitats throughout Virginia.[8,9] The VaNLA identifies large patches of natural land with at least one hundred acres of interior cover known as core areas; as well as small patches (ten to ninety-nine acres of interior cover) that are included as habitat fragments that support landscape corridors allowing for wildlife movement across broader geographical areas. Maintaining this connectivity is important in areas having few large patches of natural land.[10,11] Using these ecological core area assessments, the VaNLA has developed a landscape model of connected landscape corridors and nodes based on ecological cores from the two highest categories (i.e. C1 and C2), to create a statewide network of natural lands.[12] Exhibit (D-13) shows the Richmond to Norfolk study area with an overlay of the VaNLA network of natural lands color-coded by value.

[7] http://www.dcr.virginia.gov/natural_heritage/vclnavnla.shtml
[8] The Virginia DCR explains several key purposes of this analysis including its use: "for guidance in comprehensive planning efforts by localities; for review of proposed projects for potential impacts to ecological cores and corridors.
[9] http://www.dcr.virginia.gov/natural_heritage/vclnavnla.shtml
[10] http://www.dcr.virginia.gov/natural_heritage/vclnavnla.shtml
[11] To assess the value of these core areas and habitat fragments, the VaNLA has assigned each core and habitat fragment an Ecological Integrity Score that rates the relative contribution of that area to the surrounding ecosystem. In general, larger, more biologically diverse areas are given higher scores; and, core or habitat fragments that form part of a larger complex of natural lands are also rated higher. Likewise, core areas and habitat fragments that contribute to water quality have higher scores as well. The VaNLA has classified the compiled scores into five categories of ecological integrity: C1 - Outstanding; C2 - Very High; C3 - High; C4 - Moderate; and C5 - General.
[12] http://www.dcr.virginia.gov/natural_heritage/vclnavnla.shtml

Exhibit D-13: Preservation of Natural Land Networks and Biodiversity



Based on this knowledge of natural land networks, the selection of rail options/ alignments have tried as much as possible to avoid fragmenting natural land networks and/or maintain habitat passageways that allow for the movement of bio-diverse species of wildlife. Where fragmentation of highly valued core areas or habitats cannot be avoided, it is best to confine fragmentation to the edge areas in-order to preserve the core areas as much possible.

However, fragmentation of core areas is sometimes unavoidable due to the need to avoid other critical impacts such as structural impacts (ex. commercial and residential areas) and/or other environmental impacts (i.e. cultural resources, conservation areas, etc.) Somewhat similar to wetlands, it can be seen that wildlife corridors are a ubiquitous landscape feature, so it will impossible to completely avoid impacts in the development of new rail alignments. For those cases where it is necessary to cut across or through an established wildlife corridor or area, it will be necessary to agree on appropriate mitigation measures (possibly including wildlife underpasses or overpasses, for example) with the Virginia Department of Conservation and Recreation. In the current report, costs estimates for bridging or elevating sections of the proposed rail alignments include cost estimates for the recommended bridging of critical wetland areas that fall within the VaNLA network.

Likewise, this knowledge of potential impacts to natural land networks can be used along with other data gathered about environmental impacts in the area (i.e. wetlands, conservation areas, wildlife habits, etc.), to assist in the process of prioritizing which impacts are most critical. For example, an unmodified wetland falling within the VaNLA network of links and nodes would be viewed as having a higher priority for mitigation or avoidance than other similar wetlands.

5. HAZARDOUS MATERIALS

A database search was conducted using standard environmental record sources (see Exhibit D-14). These databases contain the names and/or locations of reported hazardous waste sites, treatment, storage and disposal facilities, pollution and hazardous waste spills, including Leaking Underground Storage Tanks (LUSTs), and landfills in Virginia. The Hazardous Materials Technical Report describes more fully the approach and analysis methods used to determine identified hazardous material sites.[13] Any incident or facility identified within the search distance was reviewed to identify past activities that could potentially result in Recognized Environmental Conditions (RECs) at the subject property or within the search distance.

Exhibit D-14: Standard Environmental Record Sources[14]

Source	Search Distance (miles)
Federal and State Equivalent – National Priorities List (NPL)	1.0
Federal and State Equivalent - Comprehensive Environmental Response, Compensation and Liability System (CERCLIS)	0.5
Federal and State Equivalent - Comprehensive Environmental Response, Compensation, and Liability System (CERCLIS), No Further Remedial Action Planned (NFRAP)	Subject and Adjoining Properties
Federal List of Treatment, Storage and Disposal (TSD) Facilities Subject to Corrective Action (CORRACTS) under the Resource Conservation and Recovery Act (RCRA)	1.0
Federal RCRA Non-CORRACTS	0.5
Federal RCRA Generators List	Subject and Adjoining Properties
Federal Emergency Response Notification System (ERNS) List	Subject Property Only
State Landfill and/or Solid Waste Disposal Site Lists	0.5
State Leaking Underground Storage Tanks (LUST) List	0.5
State Registered Underground and Aboveground Storage Tanks (USTs/ASTs) List	Subject and Adjoining Properties

At this stage of the project, superfund sites have been identified in the environmental study area. Superfund is the name given to the environmental program established to address abandoned hazardous waste sites. It is also the name of the fund established by the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (CERCLA statute, CERCLA overview). This law was enacted in the wake of the discovery of toxic waste dumps such as the Love Canal and Times Beach sites in the 1970s, and it enables the EPA to clean up such sites and/or to compel responsible parties to perform cleanups or reimburse the government for EPA-lead cleanups. Exhibit D-15 and Exhibit D-16

[13] http://www.virginiadot.org/projects/resources/TCP_Hazardous_Materials_Tech_Rpt_072704.pdf
[14] Source: 460_DEIS_Section_4_5-6.pdf

show the final NPL sites and proposed NPL sites within the environmental study area and show the site name, EPA ID, NPL status and addresses.[15, 16]

Exhibit D-15: Final National Priority List (NPL) sites from Richmond to Norfolk Environmental Study Area

Site Name	EPA ID	NPL Status	City	County	Zip
Abex Corp	VAD980551683	Final	Portsmouth	Portsmouth	23704
Atlantic Wood Industries	VAD990710410	Final	Portsmouth	Portsmouth	23704
C & R Battery	VAD049957913	Final	Richmond	Chesterfield	23234
Defense General Supply Center	VA3971520751	Final	Richmond	Chesterfield	23297
Former Nansemond Ordnance Depot	VAD123933426	Final	Suffolk	Suffolk	23434
Naval Amphibious Base	VA5170022482	Final	Norfolk	Virginia Beach	23521
Norfolk Naval Base	VA6170061463	Final	Norfolk	Norfolk	23511
Norfolk Naval Shipyard	VA1170024813	Final	Portsmouth	Portsmouth	23709
Rentokil, Inc.	VAD071040752	Final	Richmond	Henrico	23228
St Julien's Creek Annex (US Navy)	VA5170000181	Final	Chesapeake	Chesapeake	23702
Saunders Supply Co.	VAD003117389	Final	Chuckatuck	Suffolk	23432

Exhibit D-16: Proposed National Priority List (NPL) sites – Richmond to Norfolk Environmental Study Area

Site Name	EPA ID	NPL Status	City	County	Zip
Peck Iron and Metal	VAN000306115	Proposed	Portsmouth	Portsmouth	23704

In development of new alignments, as a rule, it is best to try to avoid passing through a hazardous waste site. However, should it prove necessary to pass through such a site, this is not necessarily a negative from an environmental perspective. It may then become necessary to clean up the site first before the rail alignment can pass through it; which is good for the environment but adds cost to the rail project.

6. AIR QUALITY

The Environmental Protection Agency (EPA) has set National Ambient Air Quality Standards (NAAQS) for six principal pollutants. These six principle pollutants are: Carbon Monoxide (CO), Lead, Nitrogen Dioxide (NO2), Ozone, Particle matter and Sulfur Dioxide (SO2) – these are called "criteria" pollutants. Exhibit D-17 shows the criteria for all the pollutants based on the NAAQS[17]. For the environmental study area from Richmond to Norfolk, Ozone has been the only problem criteria pollutant. The 2008 8-hour Ozone classifications for 2008 still in use today, are as follows:

[15] http://www.epa.gov/superfund/about.htm
[16] Virginia Department of Environmental Quality
[17] http://www.epa.gov/air/criteria.html

- Extreme: Area with a design value of 0.175 ppm and above.
- Severe 17: Area with a design value of 0.119 up to but not including 0.175 ppm.
- Severe 15: Area with a design value of 0.113 up to but not including 0.119 ppm.
- Serious: Area with a design value of 0.100 up to but not including 0.113 ppm.
- Moderate: Area with a design value of 0.086 up to but not including 0.100 ppm.
- Marginal: Area with a design value of 0.076 up to but not including 0.086 ppm.

On April 30, 2004 (69 FR 23941), the environmental study area was designated as "marginal nonattainment" for the 1997 ozone NAAQS, which was set at a level of 0.08 ppm or 84 ppb[18]. However, the area implemented a number of control measures that resulted in significant reductions in ozone, and the area qualified for attainment (maintenance) status in June 2007. On November 21, 2011, the DEQ Director submitted air quality designation recommendations for Virginia for the 2008 ozone National Ambient Air Quality Standard (NAAQS) to U.S. Environmental Protection Agency (EPA)[19]. In April 2012, the EPA concurred and designated this area as attaining the 2008 ozone NAAQS.

[18] Page 3, *Ozone Advance Action Plan for the Richmond-Petersburg Area,* http://www.deq.virginia.gov/Portals/0/DEQ/Air/PublicNotices/Drafts/rppro.pdf

[19] See: http://www.deq.virginia.gov/Programs/Air/AirQualityPlanningEmissions/2008OzoneStandardDesignationRecommendations.aspx

Exhibit D-17: National Ambient Air Quality Standards (NAAQS) [20]

Pollutant [final rule cite]	Primary/ Secondary		Averaging Time	Level	Form
Carbon Monoxide	Primary		8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead	Primary and Secondary		Rolling 3 month average	0.15 µg/m^3	Not to be exceeded
Nitrogen Dioxide	Primary		1-hour	100 ppb	98th percentile, averaged over 3 years
	Primary and secondary		Annual	53 ppb	Annual Mean
Ozone	Primary and Secondary		8-hour	0.075 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution	$PM_{2.5}$	Primary	Annual	12 µg/m^3	Annual mean, averaged over 3 years
		Secondary	Annual	15 µg/m^3	Annual mean, averaged over 3 years
		Primary and Secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	Primary and Secondary	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide	Primary		1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	Secondary		3-hour	0.5 ppm	Not to be exceeded more than once per year

As a result, the environmental study area has now been upgraded to an attainment area for all air pollutants. The implementation of a rail system might reasonably be expected to further improve air quality, by reducing automobile use and hence automobile emissions throughout the study area.

It should be noted that these air quality measures are all defined across a very broad geographic area. They are not location specific to the level that they are likely to impact specific rail corridor location

[20] http://www.epa.gov/air/criteria.html

decisions. The best way to optimize the performance of this measure will be to select a very attractive rail option that will be able to maximize diversion from the automobile.

7. NOISE AND VIBRATION

Railroad activity, street level traffic, and large truck traffic account for the majority of the noise and vibration impacts within the Richmond to Norfolk study area. In a future phase of work, the methodology used for measuring noise and vibration should be conducted in accordance with Federal Railroad Administration's (FRA) High-Speed Ground Transportation Noise and Vibration Impact Assessment guidelines[21], and Richmond Hampton Roads Passenger Rail Project Tier I Draft EIS report[22] . At this phase of study, only the methodology is identified. Typically, mitigations for noise and vibration are construction of noise fencing, elimination of horn noise associated with trains passing though the grade crossings, and prohibiting use of trucks on bridges. In the current study, an allowance for sound wall protection has been included where the alignment passes close to existing development in urbanized areas. This is based on a very preliminary assessment and will need to be updated in a future phase of work, based on the results of a more detailed engineering analysis of noise impacts.

8. UTILITIES

Selection of alternatives should take into consideration the potential impacts on utility lines located along the alignment. These utility lines can be identified by reviewing aerial images and aerial mapping available from several internet sites and site specific photographs[23]. Exhibit D-18 shows a sample utility line located in the environmental study area. Any utilities situated in the right-of-way may need to be relocated.

[21] High-Speed Ground Transportation Noise and Vibration Impact Assessment, U.S. Department of Transportation, Federal Railroad Administration, Washington, DC, December 1998 standards.
[22] Richmond Hampton Roads Passenger Rail Project Tier I Draft EIS report. Chapter 3 http://www.drpt.virginia.gov/projects/hamptonpassenger.aspx
[23] This information was based on the Richmond Hampton Roads Passenger Rail Project Tier I Draft EIS report. Chapter 3 http://www.drpt.virginia.gov/projects/hamptonpassenger.aspx

Exhibit D-18: Utility Line at Windsor, VA within Environmental Study Area
FROM Richmond to Norfolk

9. ENVIRONMENTAL JUSTICE

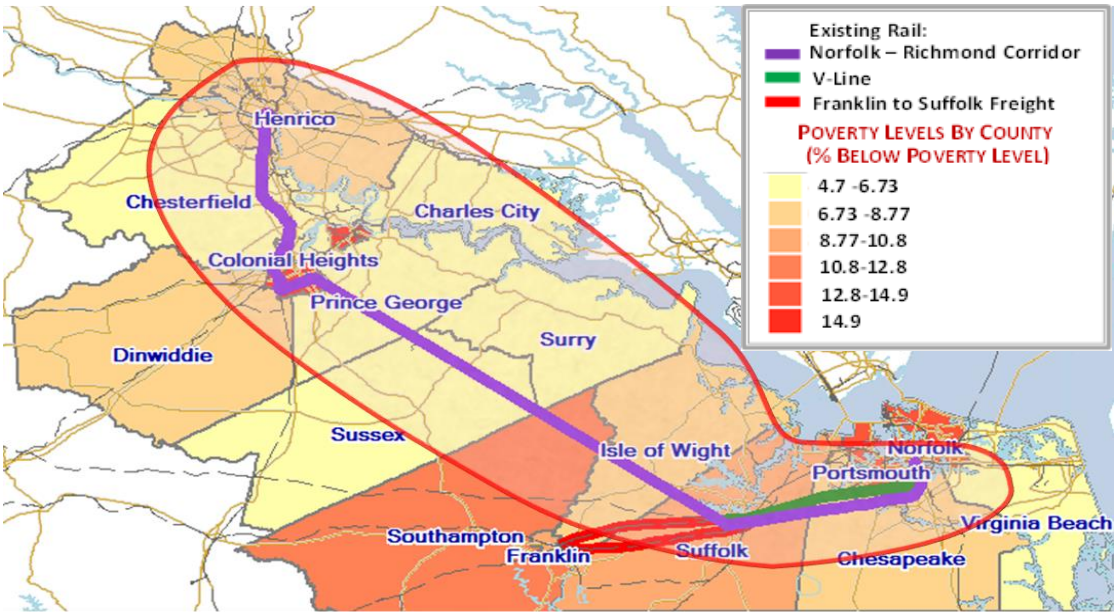
Title VI of the Civil Rights Act and the Executive Order on Environmental Justice (EJ) (#12898) do not provide specific guidance to evaluate Environmental Justice (EJ) issues within a region's transportation planning process[24]. Thus, for this study, the Delaware Valley Regional Planning Commission (DVRPC)'s 2001 EJ technical assessment[25] has been used as a model for evaluating potential EJ issues within the Richmond to Norfolk study area. Using this model, the following population groups need to be assessed as defined by the US Census Bureau:

- Non-Hispanic Minority
- Carless Households
- Households in Poverty
- Persons with a Physical Disability
- Female Head of Household with Child
- Elderly (over 75 years)
- Hispanic
- Limited English Proficiency

Poverty level data for all population groups is provided by the US Census Bureau. Exhibit D-19 shows the percent of families falling below the poverty level (by county) within the Richmond to Norfolk study area. The majority of counties within the study area have between 4% and 9% of families falling below the poverty level in family income; with Chesterfield, Charles City, Colonial Heights, Prince George's, Surry, Sussex and Virginia Beach having poverty levels that are below 7%, while the counties of Norfolk, Portsmouth and Southhampton have the highest poverty levels at over 12%.

[24] http://www.dvrpc.org/webmaps/ej
[25] http://www.dvrpc.org/webmaps/ej/

Exhibit D-19: Families below Poverty Level for Petersburg to Norfolk Environmental Study Area



Within the study area, the EJ assessment population density is minimal in the rural areas from Richmond and Petersburg to Suffolk, where most of the greenfield mileage is proposed. In the portions of the study area where the majority of the EJ population lives, the corridor tends to follow existing rail lines so development of the system is not expected to disproportionately impact the EJ population groups.. EJ issues, will need to be further analyzed in more detail in the next phase of the study.

10. GEOLOGY AND SOILS

The impact of dynamic loads of active trains on the soil may result in very intense compression cycles. For this reason, the type of soil and soil stability are very important factors. In order to provide a good foundation, thick layers of aggregate, and frequent and expensive maintenance may be required depending on the soil stability[26]. In order to determine the soil stability, identification of the soil type is essential. This could affect the final alignment location. Soil data for prime farmland is provided by the National Resource Conservation Service (NRCS), State Soil Geographic (STATSGO) Database and Soil Survey Geographic Database (SSURGO).[27] Exhibit D-20 shows usage of the Interactive Soil Survey Tool from the US Department of Agriculture's Natural Resources Conservation Services (NRCS) site to display soil data for an area located within in Charles City County, VA.
Soil data obtained from the STATSGO site is available in both tabular and spatial format for each county and is expressed in proportion values that range from 0.01 to 0.87. These values represent the probability of finding prime farmland at a geographical location and are subdivided into 5 equal intervals of classes with ranking as below[28].

[26] http://www.haywardbaker.com/WhatWeDo/Applications/RRSubgradeStabilization/default.aspx; http://www.prestogeo.com/railroad_industry; http://www.tenaxus.com/en/geosynthetics/soil-stabilization/railroads-and-airport-runways.htm.
[27] See: http://www.ncgc.nrcs.usda.gov
[28] http://www.dcr.virginia.gov/natural_heritage/documents/AgriculturalModelTechReport.pdf

Range[29]	Rank
0.8015686 – 1	5 (High)
0.6031372 – 0.8015686	4
0.4047058 – 0.6031372	3
0.2062745 – 0.4047058	2
[1]0.0078431 – 0.2062745	1 (Low)

[29] According to Agricultural model Tech Report the final agricultural model describes that the ranges and ranking were based on prime farmland grid was weighted at 80%, the historic archaeological farms were weighted at 10% and the historic architectural farms were weighted at 10%.

Exhibit D-20: Sample Usage of the USDA's Interactive Soil Survey Tool to Display Soil Data within the Lewis Tyler Lane Area of Charles City County.[30]

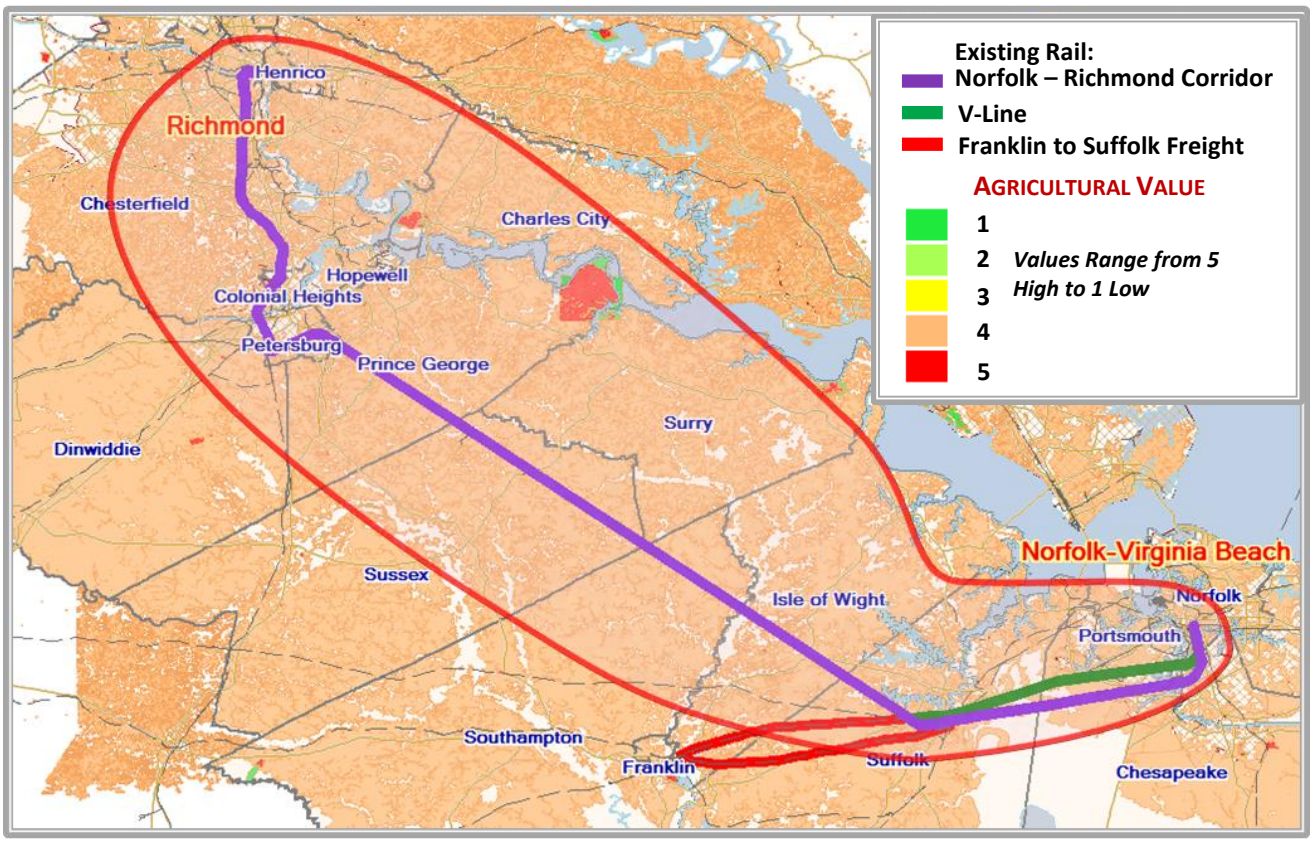
Charles City County, Virginia (VA036)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1A	Altavista fine sandy loam, 0 to 3 percent slopes	987.8	0.8%
2A	Augusta sandy loam, 0 to 2 percent slopes	972.4	0.7%
3A	Bethera silt loam, 0 to 2 percent slopes	799.9	0.6%
4A	Bibb fine sandy loam, 0 to 2 percent slopes, frequently flooded	6,744.8	5.1%
5A	Bojac loamy fine sand, 0 to 2 percent slopes	110.8	0.1%
5B	Bojac loamy fine sand, 2 to 6 percent slopes	486.6	0.4%
6B	Caroline silt loam, 2 to 6 percent slopes	311.3	0.2%
7B	Caroline-Emporia complex, 2 to 6 percent slopes	6,557.9	5.0%
7C	Caroline-Emporia complex, 6 to 10 percent slopes	241.2	0.2%
8B	Catpoint loamy	479.1	0.4%

[30] http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Exhibit D-21 shows the agricultural ranking values within the environmental study area ranging from a high of 5 to a low of 1. The ranking was based on final prime farmland and historic farm grids. It is seen that at this stage of data collection, most of the environmental study area falls under rank 4. For instance, much of Virginia's soil[31] is *Pamunkey* soil formed in stream terrace sediments in the James River drainage basin of Virginia. This soil needs to be preserved, as in recent years these soils produced high yields of corn and wheat[32]. Once rail alternatives have been selected in the next stage of the study, a more detailed soil inspection will be needed, both for development of a detailed alignment options and for identification of farmland impacts. However, it should be noted that farmland impacts for a rail system should be less than those for a comparable highway development. The agricultural land impacts can be minimized by not purchasing any wider right of way than is needed for the actual development of the rail line (typically 50') or if a wider right of way is purchased in order to secure a buffer zone, leasing back any excess right of way within prime agricultural lands for continued agricultural use.

Exhibit D-21: Agricultural Values within the Environmental Study Area



[31] According to Natural Resources Conservation Service (NRCS) of US Department of Agriculture, A state soil is a soil that has special significance to a particular state. Each state in the United States has selected a state soil, twenty of which have been legislatively established. These "Official State Soils" share the same level of distinction as official state flowers and birds. Also, representative soils have been selected for Puerto Rico and the Virgin Islands. http://soils.usda.gov/gallery/state_soils/

[32] ftp://ftp-fc.sc.egov.usda.gov/NSSC/StateSoil_Profiles/va_soil.pdf

11. TRANSPORTATION; LAND STATUS, LAND USE AND ZONING; AND SOCIOECONOMIC CONDITIONS

- Transportation: The presence of interstates, highways or any major roadway impacts must be identified for the proposed alternatives

- Land Status, Land Use, and Zoning: Right-of-ways for the proposed rail tracks must be taken into consideration as part of the study.

- Socioeconomic Conditions: The hierarchical population density of the cities and counties for the Richmond to Norfolk environmental study area are Norfolk City, Richmond City, Portsmouth City, Colonial Heights City, Virginia Beach City, Petersburg City, Henrico Co., Franklin City, Chesterfield Co., Chesapeake City, Suffolk City, Prince George County, Isle of Wight County, Dinwiddie County, Sussex County, and Surry County, with the city of Norfolk being the most densely populated and Surry County being the least populated. Major densely populated residential city areas with major transportation hubs are very important in the consideration and selection of proposed alternatives.

12. PUBLIC HEALTH AND SAFETY

Typical safety features that must be taken into consideration when proposing rail alignment alternatives include: the age of bridges that may be used by the alignment, water runoff, basal erosion, and accidents at railroad crossings. Railroad crossings, pedestrian safety and rail operations are also main factors contributing to the safety[33]. Exhibit D-22 shows a typical rail crossing located in Chesapeake, VA. Since the majority of the proposed rail system is proposed to be developed on grade-separated alignment it is anticipated that its development will improve safety. In urban areas where speeds are reduced, grade crossings may be considered with appropriate (but vastly improved) grade crossing protection and signage. Trespasser risks will be mitigated by security and sound wall fencing, particularly in urban areas, to "seal" and secure the corridor.

[33] Based on Federal Highway Railroad (FRA, Federal Highway Administration (FHWA), and Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, Virginia DRPT.

Exhibit D-22: Rail Road Crossings at Chesapeake, VA within Environmental Study Area from Petersburg to Norfolk

13. CONCLUSION AND FURTHER ANALYSIS

The environmental scanning/analysis discussed this appendix, identified and summarized potential environmental impacts within the environmental study area going from Richmond to Norfolk. This included collecting data on and mapping potential environmental impacts: conservation areas, historical resources, wetlands, wildlife resources, natural land networks, environmental justice, hazardous materials (data only), and air quality (data only). In addition, suggestions for possible mitigation measures for each of the potential environmental impact types were outlined. The highlights of the environmental scan, data collected and suggested mitigation measures are as follows:

- Conservation lands were identified and mapped within the environmental study area approximating 222,168 total acres including: 2,414 acres of forest area, 43,550 acres of federal, national and state park areas, 112,886 acres of wild life refuge and preserves area, and 63,318 acres of other conservation lands (ex. land holdings, military installation, preserves, etc.) Suggested mitigation measures include designing alignments so that they take a path that avoids or by-passes potential impacts with conservation land areas.

- Approximately 300 Protected historical resources were identified and mapped within the environmental study area including: churches, buildings, houses, etc. Suggested mitigation measures include designing alignments so that they take a path that avoids or by-passes potential impacts with protected historic sites.

- Wetlands within the environmental study area were identified and mapped. Wetland totals for the environmental study area approximated 376,850 total acres that include approximately: 311,537 acres of 'Freshwater Forested/Scrub' wetlands; 19,256 acres of 'Freshwater Emergent' wetlands; 17,547 acres of 'lake' wetlands; 13,195 acres of 'Freshwater Pond' wetlands; 11,073 acres of 'Estuarine and Marine' wetlands; 3,174 acres of

'Riverine' wetlands; 812 acres of 'Estuarine and Marine Deepwater' wetlands; and 254 acres of 'other' wetlands. Suggested mitigation for impacted wetlands include coordinating with the US Army Corps of Engineers to design appropriate mitigating measures that meet compliance with Executive Order 1199034 for Protection of Wetlands, including avoiding, filling, bridging, or replacing wetlands at the required ratios.

- Wildlife resources within the environmental study area were identified and mapped including the location of: lakes creeks, reservoirs, wildlife preserves, bird and wild life trails, fishing areas, and boating access sites. Suggested mitigation measures include designing alignments so that they take a path that avoids or by-passes potential impacts with wildlife preserves and wildlife resources.

- The environmental study area was also reviewed with regard to the location of important natural land links, nodes, and core areas identified by the VaNLA as being vital to the preservation of natural land networks and biodiversity in the regional ecosystem. Vital intact natural land networks in the HRTPO region were identified and mapped. Suggested mitigation measures include designing alignments so that they take a path that avoids fragmenting intact land networks and intact core areas that have a high to excellent ecological integrity score rating. Where fragmentation cannot be avoided, it is recommended to keep impacts confined to the edges of highly valued core areas and/or to provide natural passageways that allow for the natural movement or migration of plant and animal species.

- Hazardous material superfund sites of 11 final NPL sites and 1 proposed NPL site were identified within the Richmond to Norfolk environmental study area. These issues will be more thoroughly examined in the next phase of the study once route alignment options have been decided upon for further study.

- Air quality within the Richmond to Norfolk environmental study area shows that the only pollutant that has recently been in the marginal levels was ozone. However in April 2012 the EPA designated the area as in compliance for ozone under the 2008 standards, so the study area is now in compliance status for all air pollutants.

- Other human environmental elements that include noise and vibrations, utilities, environmental justice, geology and soils, transportation, land status, land use, and zoning, socioeconomic conditions, and public health and safety were briefly reviewed at a landscape level scan and should be discussed in more thorough detail in the next phase of the study once the final route alignment options have been selected.

Using the summary of identified environmental resources and potential environmental impacts outlined in this chapter as a base, a more intensive environmental study (Service NEPA) can be performed in the next phase of the study once the route alignment options have been even more carefully defined and optimized.

[34] http://www.archives.gov/federal-register/codification/executive-order/11990.html

APPENDIX E: PHASE 2A ENGINEERING FIELD SURVEY: PETERSBURG TO NORFOLK

1. INTRODUCTION

One of the key elements in developing higher and high speed intercity passenger rail options for the Norfolk to Richmond Corridor is a review of the existing rail infrastructure, along with development of an understanding of the potential corridor constraints and opportunities for improvements for supporting passenger rail service. As a part of the Phase 2A data collection effort in 2012, a field survey for understanding the general topographic, demographic and environmental conditions along potential Greenfield corridors between Norfolk, Petersburg and Richmond was undertaken. For the purpose of a preliminary analysis, this assessment was accomplished by using the following process:

- Gathering of information from a route review of the existing rail corridor from Norfolk – Suffolk – Petersburg – Richmond area, and to understand the existing conditions along corridors that might include potential new Greenfield alignments.
- Gathering of information from prior Engineering analyses of the Norfolk – Richmond – Washington, DC and Newport News – Richmond – Washington, DC rail corridors and Preliminary Vision Plan including a review of available right-of-way documentation and cost data.
- Identification of typical corridor infrastructure issues and constraints.
- Identification of the design standards typically applied for the various classes of passenger rail service.
- Development of an initial conceptual capital cost estimate of rail improvements to support the implementation of high speed passenger rail service.

It should be noted that for the purposes of this preliminary analysis no detailed corridor mapping or route specific inspection of the potential Greenfield rail corridors was completed, since exact alignments for the prospective Greenfield routes has yet to be determined.

This Appendix documents the Engineering Database that includes the *TRACKMAN*™ databases, and the preliminary infrastructure data that was collected for the high speed and intercity passenger rail assessment. It presents an overview of existing conditions between Petersburg/Richmond and the Norfolk area. Typical design standards used for the development of the various speeds of passenger rail service and unit cost data are included in Chapter 4 in the main body of this report.

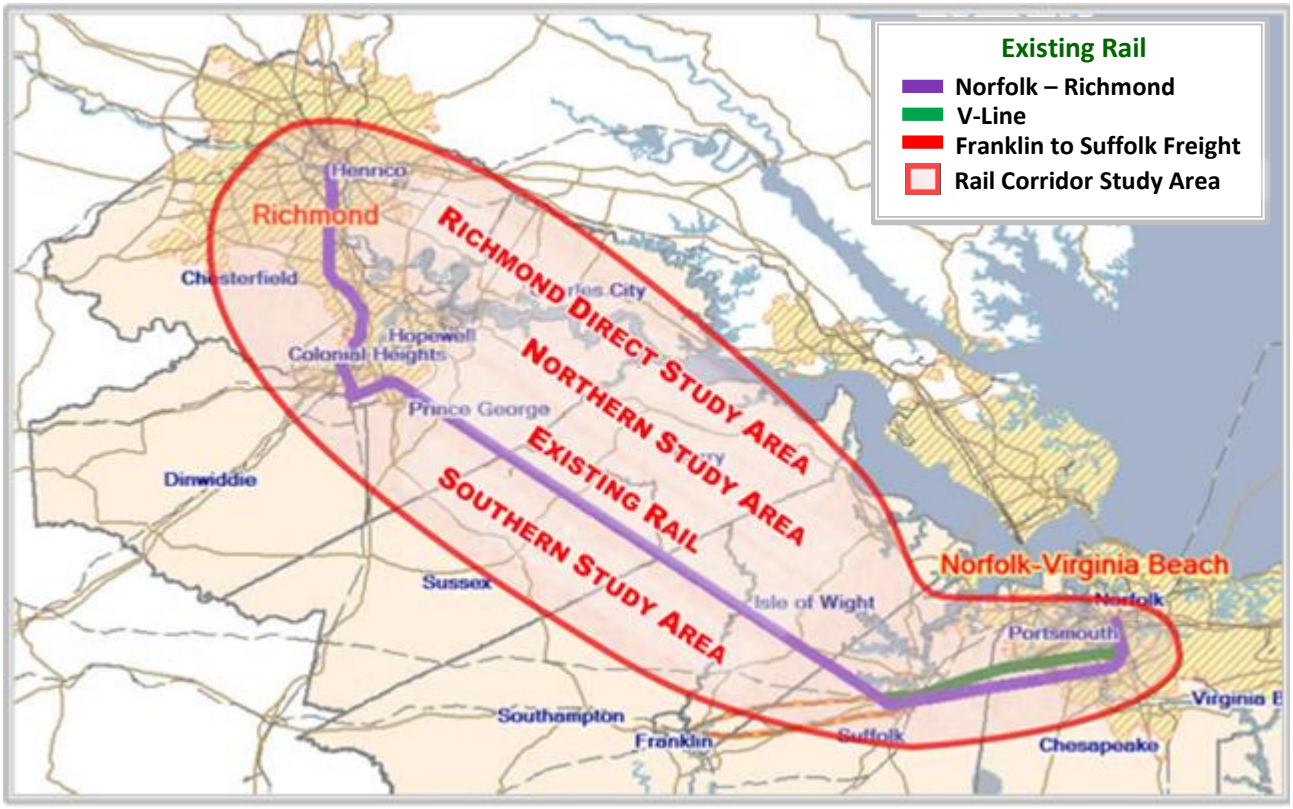
2. POTENTIAL HIGH SPEED ROUTES FROM PETERSBURG TO NORFOLK

To support the data collection effort in Phase 2B, it was clear that at least a preliminary definition of the Environmental Study Area would be needed. The Environmental Study Area is considered to be the potential region or envelope within which potential rail alignments might lie. This contrasts with a broader "Study Area" or Zone System that is used for ridership forecasting. Because of the ability to use auto as an access mode as well as connecting rail service, the "Ridership Study Area" encompasses a much larger territory than does the "Environmental Study Area." The Environmental Study Area defines the geographic boundaries of the area within which engineering and environmental data must be collected and reviewed. This Environmental Study Area is shown in Exhibit 1.

These options allow a great deal of flexibility for locating the final alignments between Richmond and the west end of Suffolk within a broad envelope. All options assume that the existing "V-line" right-of-way will be used through downtown Suffolk to Norfolk. As seen in Exhibit 1 an envelope has been created to

define the Environmental Study Area. The engineering, environmental databases are focused within this envelope. The major areas of concern along the existing rail alignment are Disputanta, Waverly, Wakefield, Ivor, Zuni and Windsor. These areas are discussed in the following sections.

Exhibit 1: Norfolk to Richmond Environmental Study Area



*Alignment will not be determined until the Tier II Environmental Process is complete.

Clearly, one possible option is to develop a high speed rail service from Petersburg to Suffolk paralleling the existing Norfolk Southern tracks. Presumably the existing tracks would not be used because they are needed for the current freight service, and Norfolk Southern has a policy of not permitting speeds above 79 mph on tracks they own. Therefore, the task is to assess the corridor in close proximity, either within the existing right-of-way or closely paralleling the right-of-way, for the ability to add high speed tracks to the corridor. In a general sense, since the existing rail alignment is straight, geometry is not the challenge, but there are a number of instances (particularly in small towns) where adjacent development closely hugs the right-of-way. The need for potential property displacement is a definite challenge for the development of this alignment – although any greenfield alignments will also require displacements.

3. *TRACKMAN™* DATABASE

The *TRACKMAN™* Track Management System was used in this analysis to provide a milepost-by-milepost record of the rail gradients and track geometry of the existing right-of-way. The data that has been compiled from existing sources includes railroad timetables, track charts, ordinance survey maps, and land stat photometry for the existing NS alignment and will be complied for the possible greenfield alignments to be developed in the next phase of the study. The following has been assessed for the NS route alignment and will similarly be used to assess the other possible corridor options:

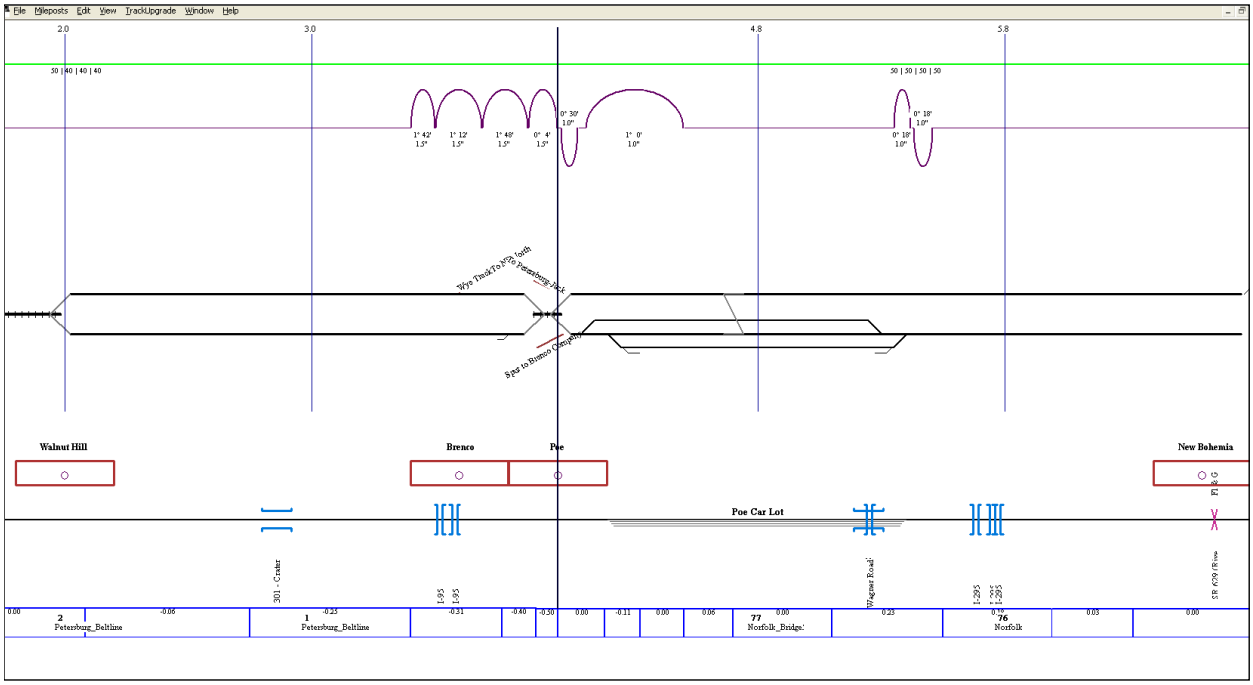
- Potential track upgrades
- Improvements for different passenger rail speeds
- Operations

The possible alternatives will be derived from the preliminary analysis of the environmental data and engineering standards required for each technology. The options are at the conceptual landscape level of route assessment and will serve as preliminary options. However, entirely new options could be selected in the Tier I Environmental Alternative Analysis in the Analysis Phase of the project.

Engineering notes were developed and entered into the *TRACKMAN™* program, which is used to maintain the database, to provide a clear understanding of basic track conditions, and the upgrades needed to support higher passenger rail speeds. *LOCOMOTION™* and *MISS-IT™* are used for operation simulations.

A sample output from *TRACKMAN™* is given below in Exhibit 2. The full *TRACKMAN™* file for the existing Norfolk Southern rail route is given at the end of this Appendix.

Exhibit 2: Sample NS Petersburg Data



4. PRELIMINARY PHASE 2A INFRASTRUCTURE DATA COLLECTION FOR PETERSBURG TO NORFOLK

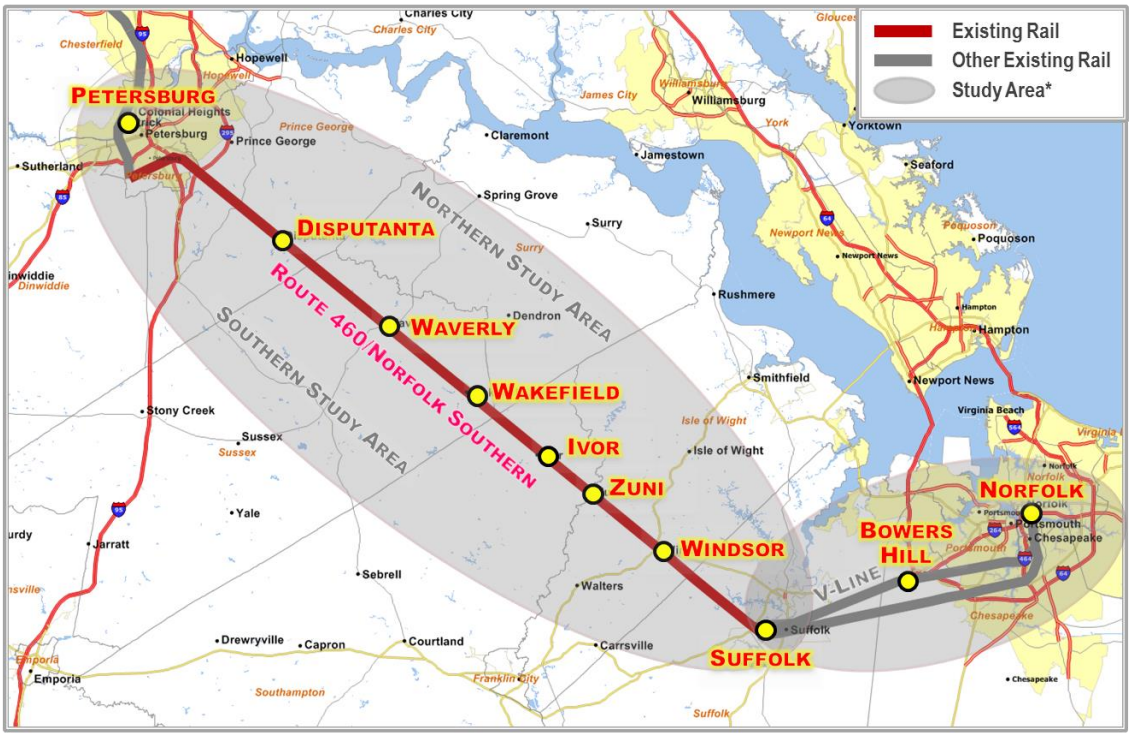
In the earlier phase of the study of the preliminary Vision Plan, existing passenger rail conditions were examined for the Norfolk Southern and the CSX Transportation (CSXT) rail lines between Richmond and the Hampton Roads area along with field review of the section of the Richmond to Petersburg rail lines south of the Amtrak Staples Mill Station. In this phase of the study, possible greenfield options from the Richmond area to Norfolk were added. The earlier inspection of the existing NS corridor from Norfolk to Petersburg was updated and a thorough inspection (as is possible from publicly accessible locations) was conducted. The existing conditions review was completed by a survey of the potential rail corridors together with detailed Google mapping. The existing conditions review was accomplished by driving to access crossing (intersecting streets, overpasses) of the rail lines and seeing the rail corridors at these access points.

The following photos provide an overview of the existing conditions along the rail corridor alternatives between Petersburg and Norfolk. In addition, Harbor Park Station in Norfolk was reviewed.

4.1 NORFOLK SOUTHERN EXISTING RAILROAD– SUFFOLK TO PETERSBURG

From Petersburg to Suffolk, one alternative is to follow the existing NS rail alignment. (See Exhibit 3) As part of Step 1 this has been recently upgraded to allow 79-mph passenger rail from Petersburg to Norfolk.

Exhibit 3: NS Existing Alignment from Suffolk to Petersburg



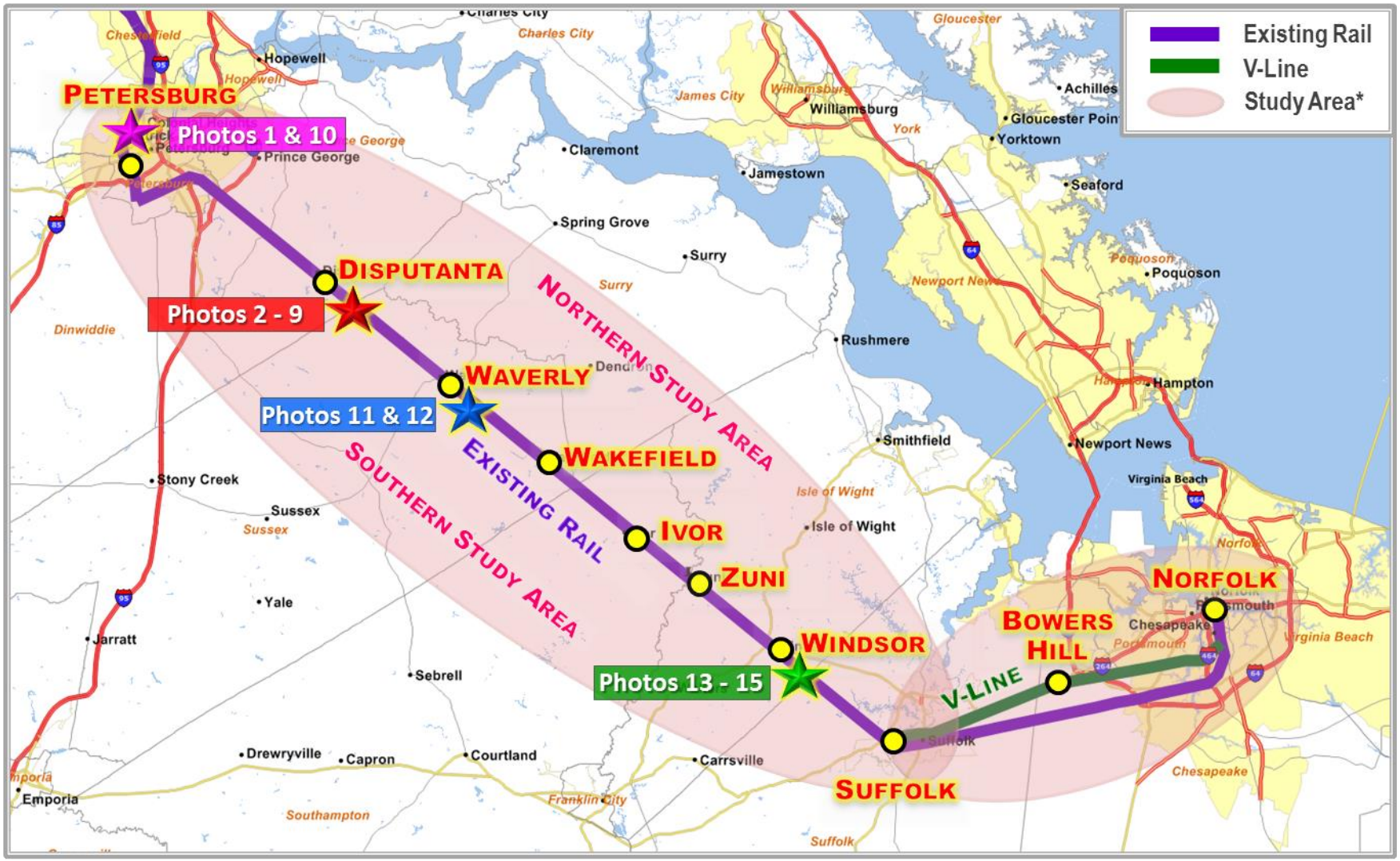
*Alignment will not be determined until the Tier II Environmental Process is complete.

The improvements that have been made from the new connection at Collier (in south Petersburg) to Norfolk include:

- New bidirectional signaling system
- New crossovers
- Track speed improvements

Some of the improvements can be seen in Photos 1 and 2 below that show the new CSXT/NS connection at Collier, and the new bidirectional signaling system.

Exhibit 4: Photo Locations along NS Existing Alignment from Suffolk to Petersburg



*Alignment will not be determined until the Tier II Environmental Process is complete.

Photo 1: New Collier connection near Halifax Road south of Petersburg.

Photo 2: New Bi-directional signaling system at Disputanta, VA.

The assumption is that in order to run high speed service at least one or two new tracks must be added to the corridor separate from the existing rail lines. Norfolk Southern's policy does not allow trains with speeds greater than 79 mph[1]. The Federal Railroad Administration (FRA) only requires 14 feet of track separation but according to *Adjacent Track Rule*[2] the track separation should be at least 25 feet to avoid interference with track maintenance operations. Increased spacing even beyond 25 feet will be considered where practical.

For adding track to the rail corridor, photos 3 through 15 (also located in Exhibit 4) show the area adjacent to the NS existing track with major areas of concerns being Disputanta, Waverly, Wakefield, Ivor, Zuni, and Windsor.

[1]Norfolk Southern to increase maximum speeds for Amtrak trains between Norfolk and Petersburg.
http://www.nscorp.com/nscportal/nscorp/Media/News%20Releases/2012/ns_amtrak_speed.html
[2] http://www.gpo.gov/fdsys/pkg/FR-2011-11-30/pdf/2011-30250.pdf

Some of the environmental issues noted along the existing NS tracks were:

- The presence of small towns with residential property, historic places
- Presence of wetlands very close to the existing NS tracks
- Presence of over and under bridges which narrow downs the track separation distance, or else requires replacement of the bridges
- Highway crossing to develop grade separations for a high speed rail
- Access to private lands across tracks must be maintained
- Rail-served industry access must be maintained
- Rail access to connecting lines and junctions must be maintained

Photo 3: Railroad crossing at Disputanta, VA would require grade separation.

Photo 4: Industrial development near tracks at Disputanta, VA

Photo 5: Overhead rail bridge on Golf Course Drive at Disputanta, VA would have to be widened or replaced.

Photo 6: On south side of the NS Tracks Prince George Golf Course entrance at Disputanta, VA.

Photo 7: On south side of the NS tracks Bakers Pond at Disputanta, VA.

Photo 8: Private grade crossing at Disputanta, VA.

Another track may be added under the bridge, which should be at least 25 feet away according the FRA adjacent track rule for not interfering with freight operations.

Photo 9: Bridge at Disputanta, VA allows room for one track at 14 feet center, but not two tracks or wider separation. This bridge may have to be replaced to allow room for additional tracks.

Photo 10: Junction to Old NS Mainline at Poe, near Petersburg. Room for new track on the south side here would not interfere with the junction on the north side.

Photo 11: Old building in close proximity to tracks at Waverly, VA.

Photo 12: Room to add track north of existing rail alignment at Waverly, VA.

Photo 13: Industrial access at Windsor, VA.

Photo 14: Streets on both sides of tracks at Windsor, VA.

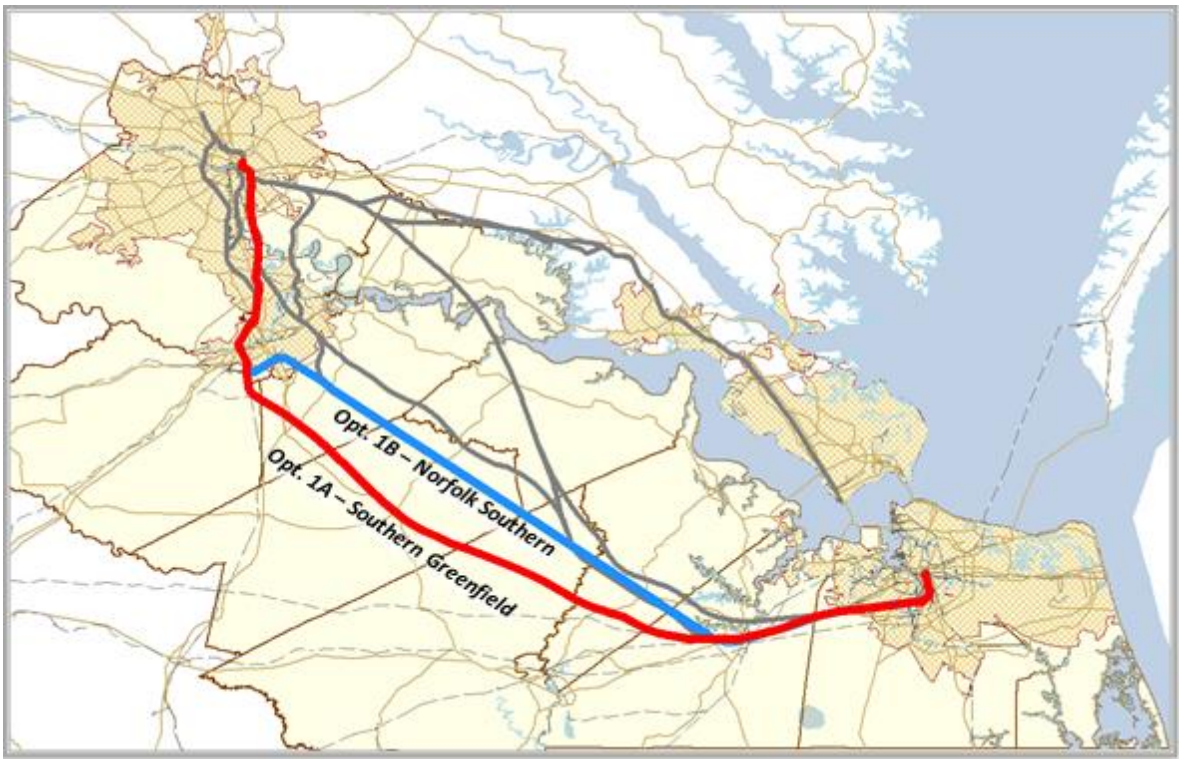
Photo 15: Railroad crossover at Windsor, VA.

The purpose of this inspection effort was to provide data for use in the preliminary engineering and environmental work for developing a capital cost estimate for improving the existing rail corridor. The example photographs show the specific kinds of measures that will be needed to implement high speed rail service while avoiding interference with existing freight operations.

4.2 POSSIBLE SOUTHERN GREENFIELD – SUFFOLK TO PETERSBURG OPTION 1A

The Suffolk to Petersburg segment of Option 1A, otherwise known as the Southern Greenfield, has also been reviewed (See Exhibit 5). The original concept was to follow the abandoned Virginian right-of-way as far as possible, to the vicinity of Walters. From Walters, a new greenfield would head straight towards Collier to meet CSX. But this has two problems: at the east end, this would pass through the middle of the town of Walters. At the west end, Photo 16 shows a residential community and Photo 17 shows Richard Bland College which lie along this direct path between Walters and Collier. However, these obstacles can be avoided by shifting the conceptual option. The revised greenfield would pass north of Walters, rather than directly through it. At the west end, the option is shifted south to meet CSX at the south end of Collier Yard, (near the SEHSR's[3] Burgess Connection) rather than at the north end. This eliminates any conflicts with the college and golf course community. See Exhibit 6 for photo locations within the possible southern greenfield study area.

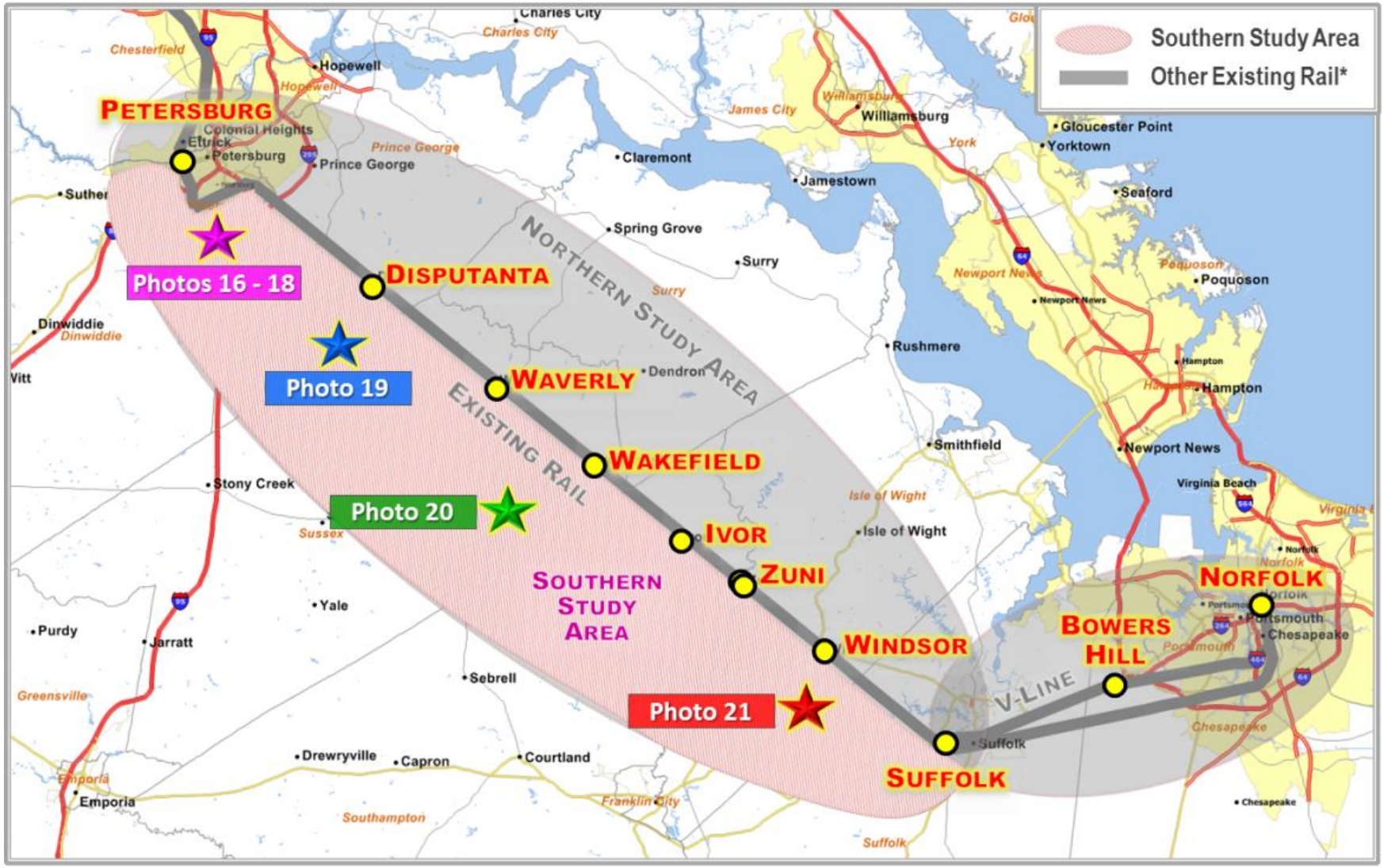
Exhibit 5: Southern Greenfield Option 1A from Suffolk to Petersburg



*Alignment will not be determined until the Tier II Environmental Process is complete.

[3] SEHSR – Southeast High Speed Rail

Exhibit 6: Photo Locations along Possible Southern Greenfield Option 1A from Suffolk to Petersburg



*Alignment will not be determined until the Tier II Environmental Process is complete.

Photo 16: Golf course and residential community at Halifax Road near Petersburg.

Photo 17: Richard Bland College at Petersburg

From Burgess north to Petersburg, the SEHSR and Norfolk services could share a dedicated passenger track around Collier yard. From Burgess, the southern high speed line would head southeast towards Suffolk, Photo 18 shows the open countryside looking east from Burgess. Photos 19 through 21 show open country side along the southern alignment, which would connect the south end of the Collier Yard to the western outskirts of Suffolk.

The greenfield right-of-way would skirt the Warwick Swamp heading through generally open countryside (cotton fields and scrub forest) to meet the abandoned "Virginian" rail right-of-way somewhere in the vicinity of Walters, VA. The alignment would then continue along the abandoned "V-Line" right-of-way into downtown Suffolk.

Photo 18: Open country side looking east, from the south end of Collier Yard.

Photo 19: Pine Scrub Forest territory to be traversed near Disputanta.

Photo 20: Cotton field in general area to be traversed near Wakefield.

Photo 21: Section of abandoned “Virginian” railroad right-of-way from Suffolk to Walters.

4.3 POSSIBLE NORTHERN GREENFIELD – SUFFOLK TO HOPEWELL – OPTION 2A

A northern greenfield from Petersburg to Suffolk (see Exhibit 7) might roughly parallel route 10 from south of James River Bridge near Hopewell to Zuni and then parallel the utility line and NS rail line from Zuni to Suffolk. Photos 22-25 show the bridge over James River on I-295 near Hopewell, the Median on Interstate I-295 near Prince George which has room to add track, Tucker Swamp which was identified as a potential environmental concern, and the utility line which is parallel to NS alignment/US Route 460. These photos are identified in Exhibit 8. The generic Greenfield would be located by identifying and avoiding the Tucker Swamp area, and utilizing the I-295 median to pass through the Petersburg/Hopewell community.

Exhibit 7: Northern Greenfield from Suffolk to Hopewell

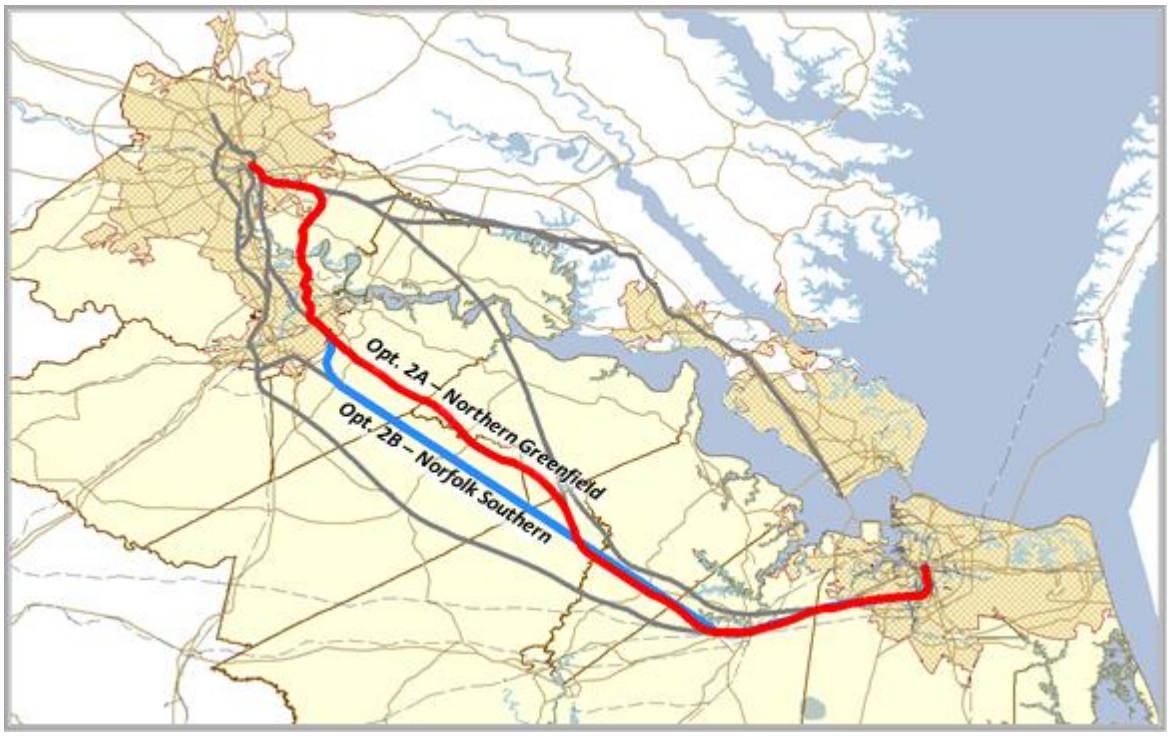
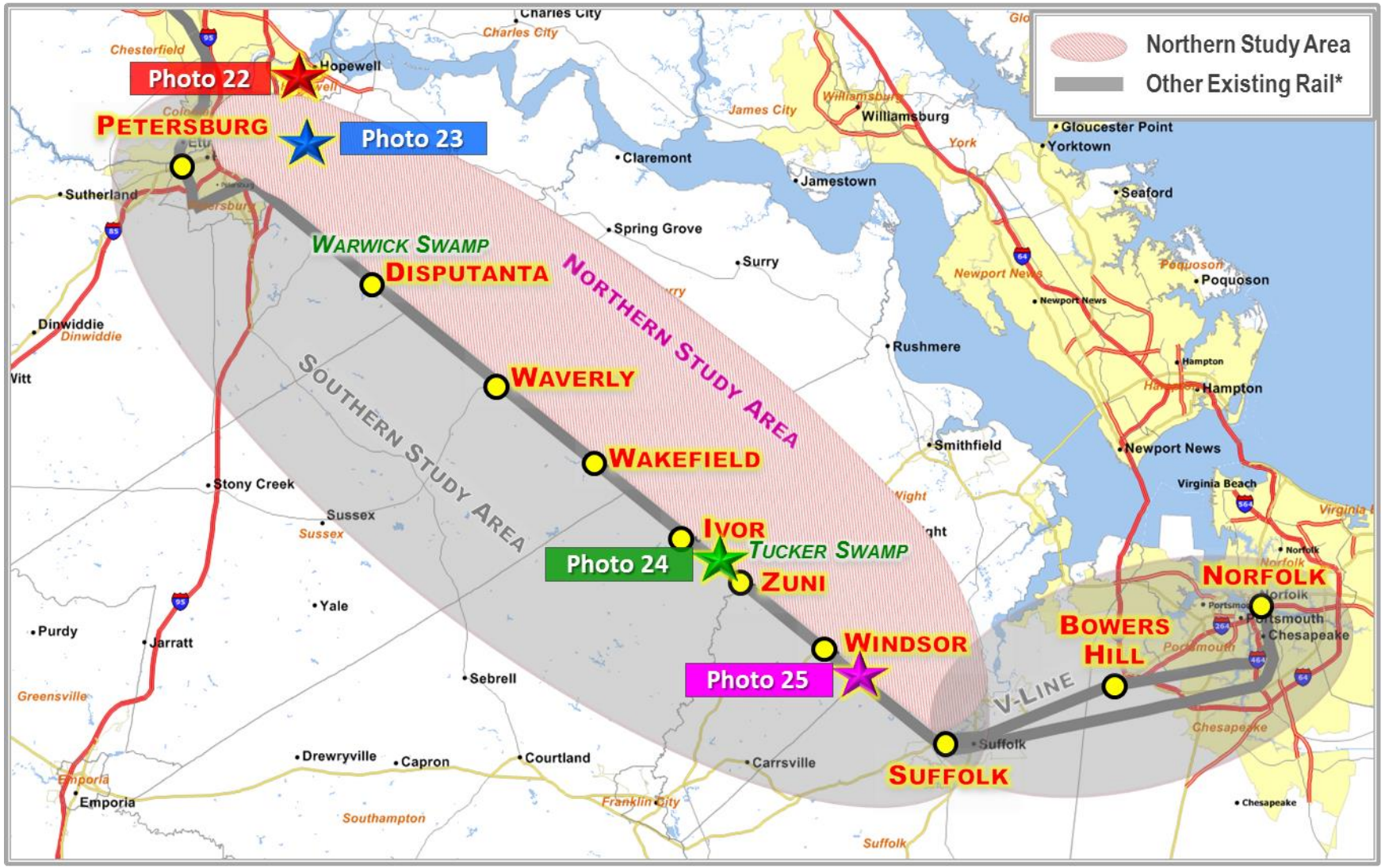


Exhibit 8 Photo Locations along Northern Greenfield from Suffolk to Hopewell



*Alignment will not be determined until the Tier II Environmental Process is complete.

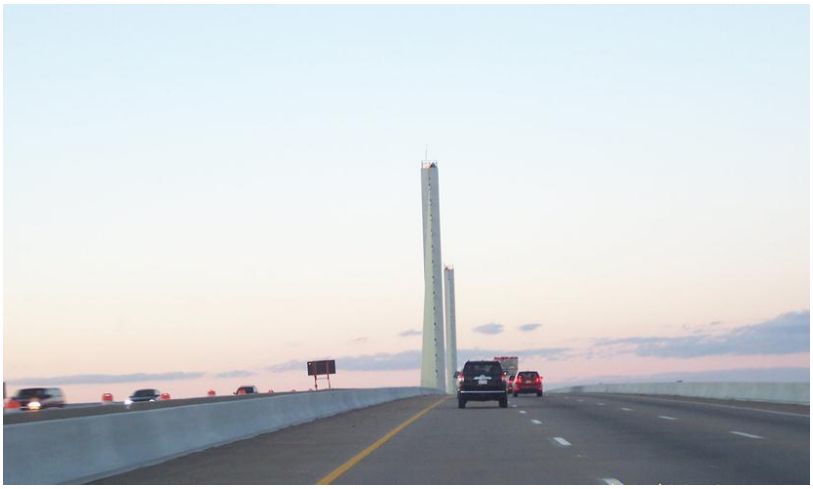


Photo 22: Bridge on I-295 near Hopewell James River.

Photo 23: Median on I-295 near Prince George.

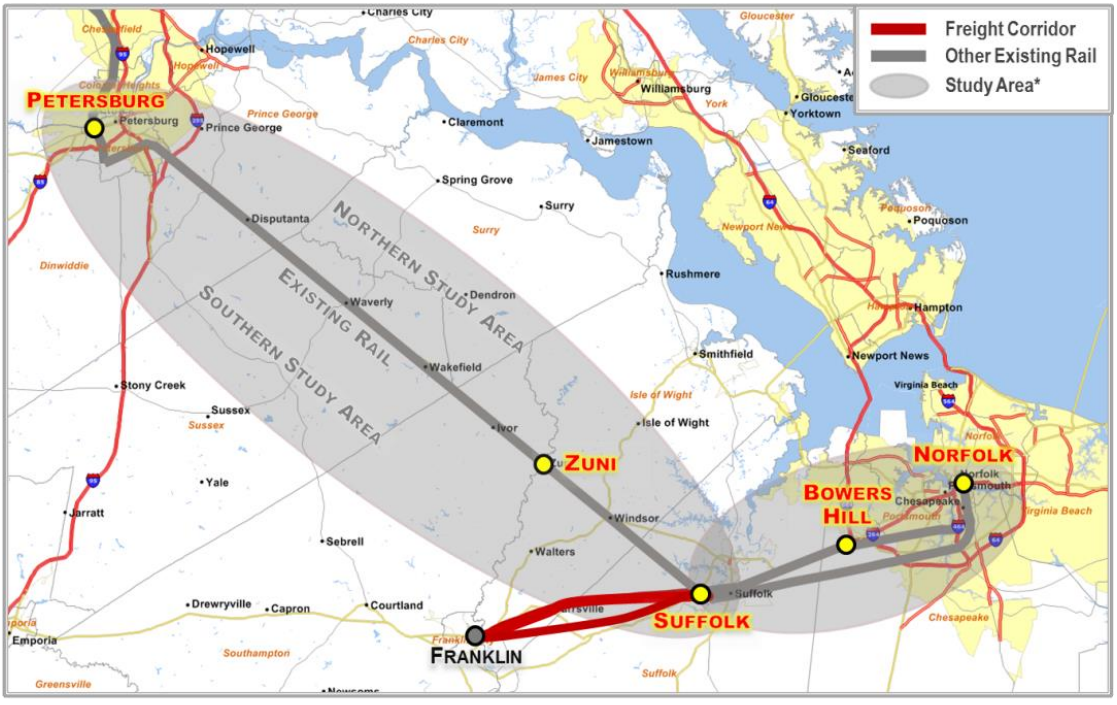
Photo 24: Tucker Swamp at the NS alignment.

Photo 25: Northern greenfield - utility line corridor at Windsor.

4.4 EXISTING RAIL – FRANKLIN TO SUFFOLK, AND DOWNTOWN SUFFOLK

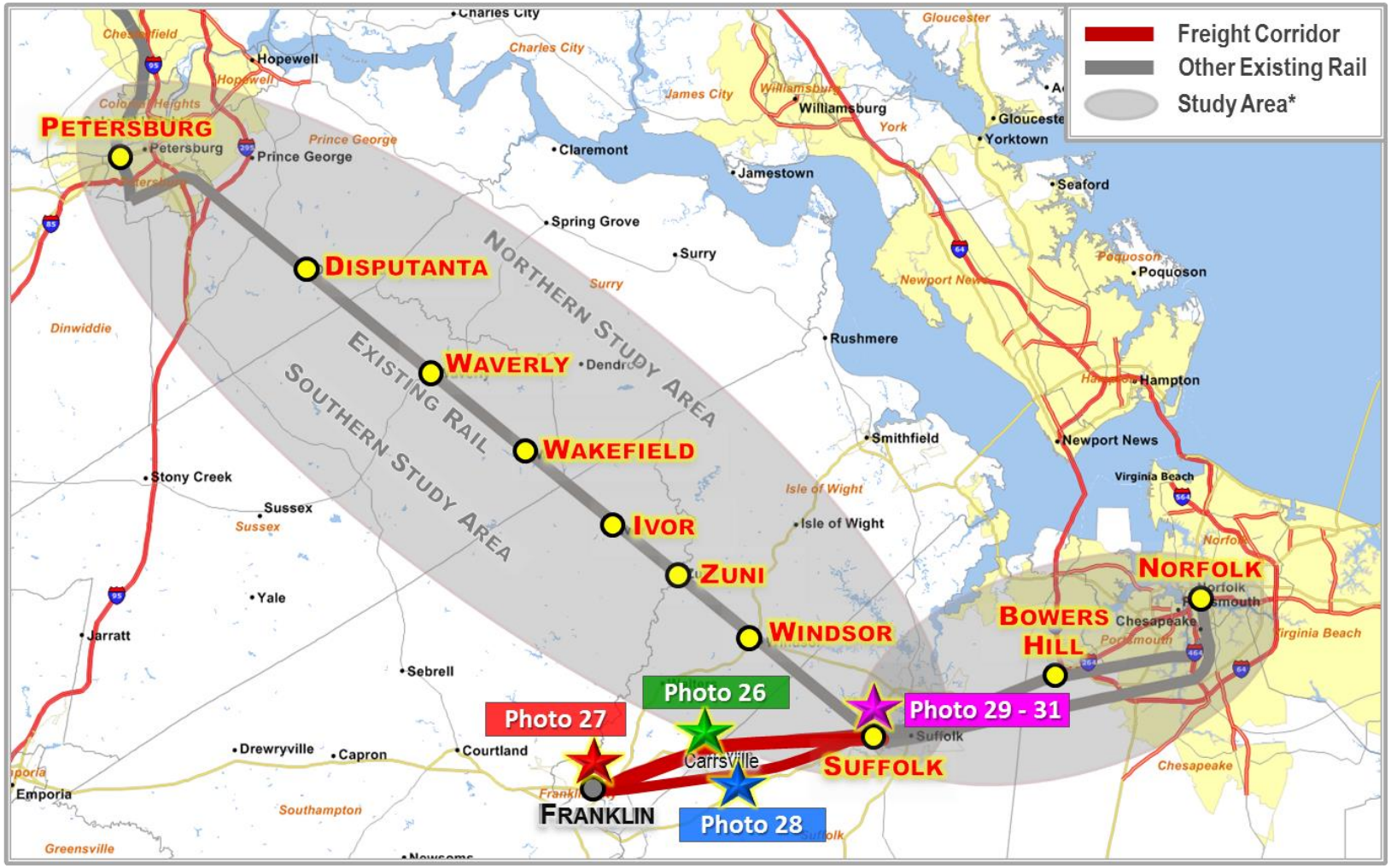
A possible freight rail alternative for developing a dedicated passenger line through downtown Suffolk could alleviate potential conflicts with CSXT double track container trains that now use the CSX Portsmouth subdivision through downtown Suffolk on their way to VPA container port. It is intended for the development of an alternative rail access for CSXT container trains, to avoid conflict with passenger trains through downtown Suffolk on the proposed "V-Line alignment". The existing CSXT and NS freight lines from Franklin to Suffolk (See Exhibit 9) have been reviewed in the following photos from 26 through 28. These photos show that the NS line is in good condition, and could be a practical alternative to the CSXT line through downtown Suffolk. Exhibit 10 shows the location of these photos along the existing rail line Franklin to Suffolk and downtown Suffolk.

Exhibit 9: Franklin to Suffolk Freight Alternative



*Alignment will not be determined until the Tier II Environmental Process is complete.

Exhibit 10: Photo Locations along Franklin to Suffolk Freight Alternative



*Alignment will not be determined until the Tier II Environmental Process is complete.

Photo 26: CSXT Portsmouth subdivision near Franklin. This is current route for CSXT double stack trains.

Photo 27: NS Bridge over CSXT in Franklin.

Photo 28: Welded rail on NS line from Franklin to Suffolk.

Photo 29 shows the roadway that has displaced about 0.8 miles of railroad right-of-way in downtown Suffolk. It extends from the junction of W Constance road/Prentis Street to the Suffolk Seaboard Station. This was a recently constructed roadway which can be seen in Photo 30. In the vicinity of this old seaboard Suffolk station, there is a development on the other side of the CSXT tracks while there is more room to add track if necessary, on the station side. This suggests that the station be shifted back from its current place to make room for added tracks if the CSXT freight traffic cannot be relocated.

Photo 29: Rail right-of-way taken over by Highway close to Suffolk Old Station.

Photo 30: Seaboard Suffolk Old Station.

To implement the Franklin to Suffolk rerouting of CSXT trains, a grade separation may be needed at the rail junction in downtown Suffolk, as shown in Photo 31.

Photo 31: Part of Franklin to Suffolk freight reroute.

4.5 "V" LINE EXISTING RAIL – NORFOLK TO SUFFOLK

The corridor from Norfolk to Suffolk is heavily built up, and there are only a limited number of ways of getting between the two cities because of the significant environmental obstacles as well, particularly, the Dismal Swamp.

- Currently NS has a double tracked mainline from Suffolk to Norfolk which carries heavy freight traffic and additionally, the Virginia Department of Rail and Public Transportation (DRPT) has purchased up to three slots for operating Amtrak passenger service over this line into downtown Norfolk.
- However, NS also has a parallel, partially abandoned line, the "V Line" which could provide a dedicated passenger access route into downtown Norfolk separate from the current freight line. DRPT's Hampton Roads Tier I FEIS has selected this route.

As a result, this analysis assumes that the "V" line alternative will be followed, for the following reasons. The "V" line alternative follows the US Route 460 alignment north of the Dismal Swamp, whereas the existing NS mainline goes directly across the swamp. Adding tracks to the existing NS alignment would either entail filling parts of the swamp – unlikely to be environmentally acceptable – or else bridging the swamp, which would be very expensive. It is likely that the Dismal Swamp issue alone would be sufficient to environmentally disqualify such an alternative. There are additional operational issues along the NS mainline at Portlock Yard which would also be bypassed by using the proposed "V Line" alignment.

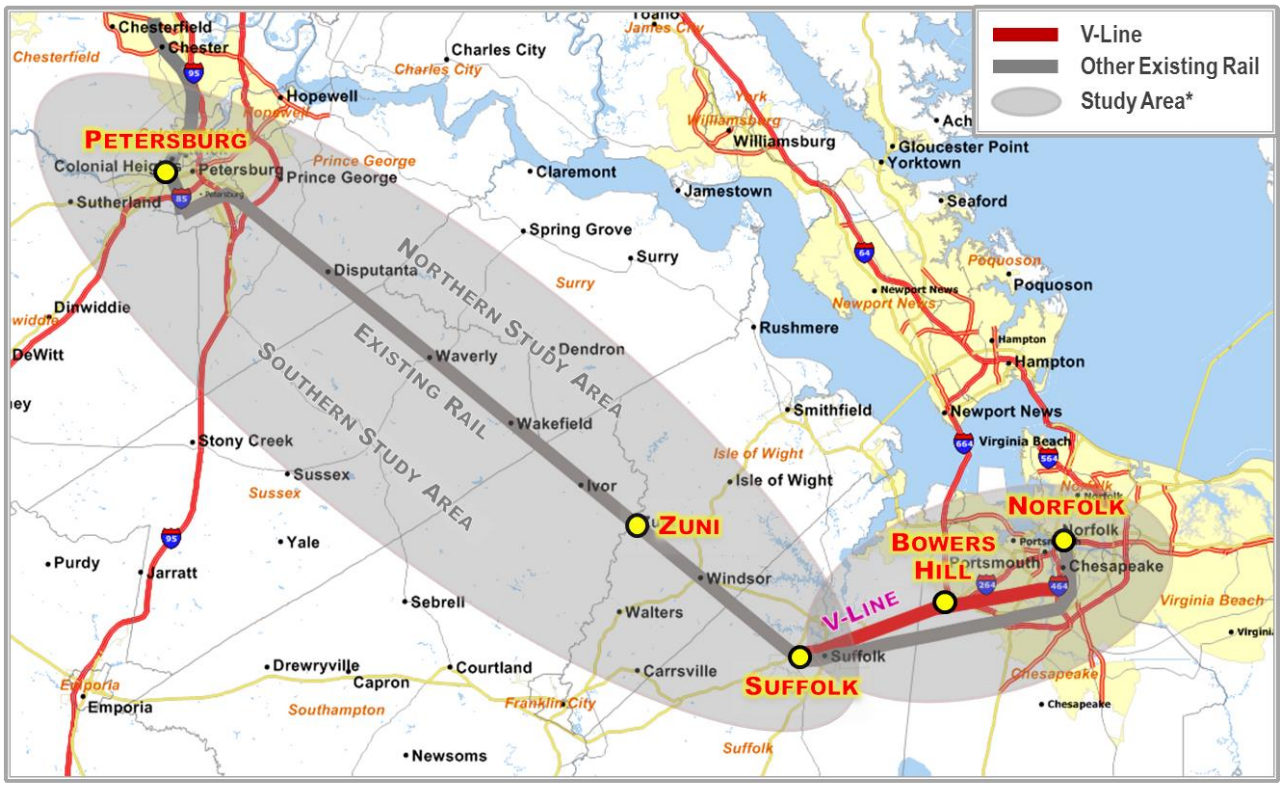
However, development of the "V Line" option is not without some challenges:

- At Algren on the west side of Suffolk, a new connection track may be needed to link the Norfolk Southern mainline to the CSXT Portsmouth subdivision through Suffolk.
- From Algren through Suffolk, passenger trains may need to share tracks with CSXT double stack trains to a connection with the Commonwealth Railway, which provides access to the Portsmouth Marine Terminal at Craney Island. As already described, the right-of-way is highly restricted through downtown Suffolk, since the abandoned former Virginian right-of-way has been converted into a city street (Prentis Street) occupying the land that would be needed to develop a separated passenger alignment through this area.
- Beyond the Commonwealth Railway, the CSXT Portsmouth subdivision is lightly-used to its junction with the abandoned "V-Line" in the vicinity of the Hampton Roads Executive Airport.

- The tracks are in place, but the "V-Line" is out of service from the Hampton Roads Executive Airport to the Cavalier Industrial Park, just west of Cavalier Boulevard.
- From the Cavalier Industrial Park, crossing the Western Branch of the Elizabeth River on a lift bridge, to NS Main Line junction north of Portlock Yard (Seaboard Avenue and Richmond Streets in South Norfolk in Chesapeake) the "V-Line" is lightly used for industrial traffic.
- From the "V" Line junction into the Harbor Park train station (Seen in Photo 36), passenger trains must share right-of-way with the NS main line. This section includes a second major bridge crossing the Southern Branch of the Elizabeth River just south of the Harbor Park station. In this area, an out-of-service former Virginian Railroad bascule bridge is proposed to be rehabilitated and restored to service so as not to displace freight capacity of the existing NS main line.

These challenges will be shown in the following photos 32 through 36 covering Portsmouth, Chesapeake, and Norfolk following the V-line track from Norfolk to Suffolk (as shown in Exhibit 11). The location of these photos are shown in Exhibit 12.

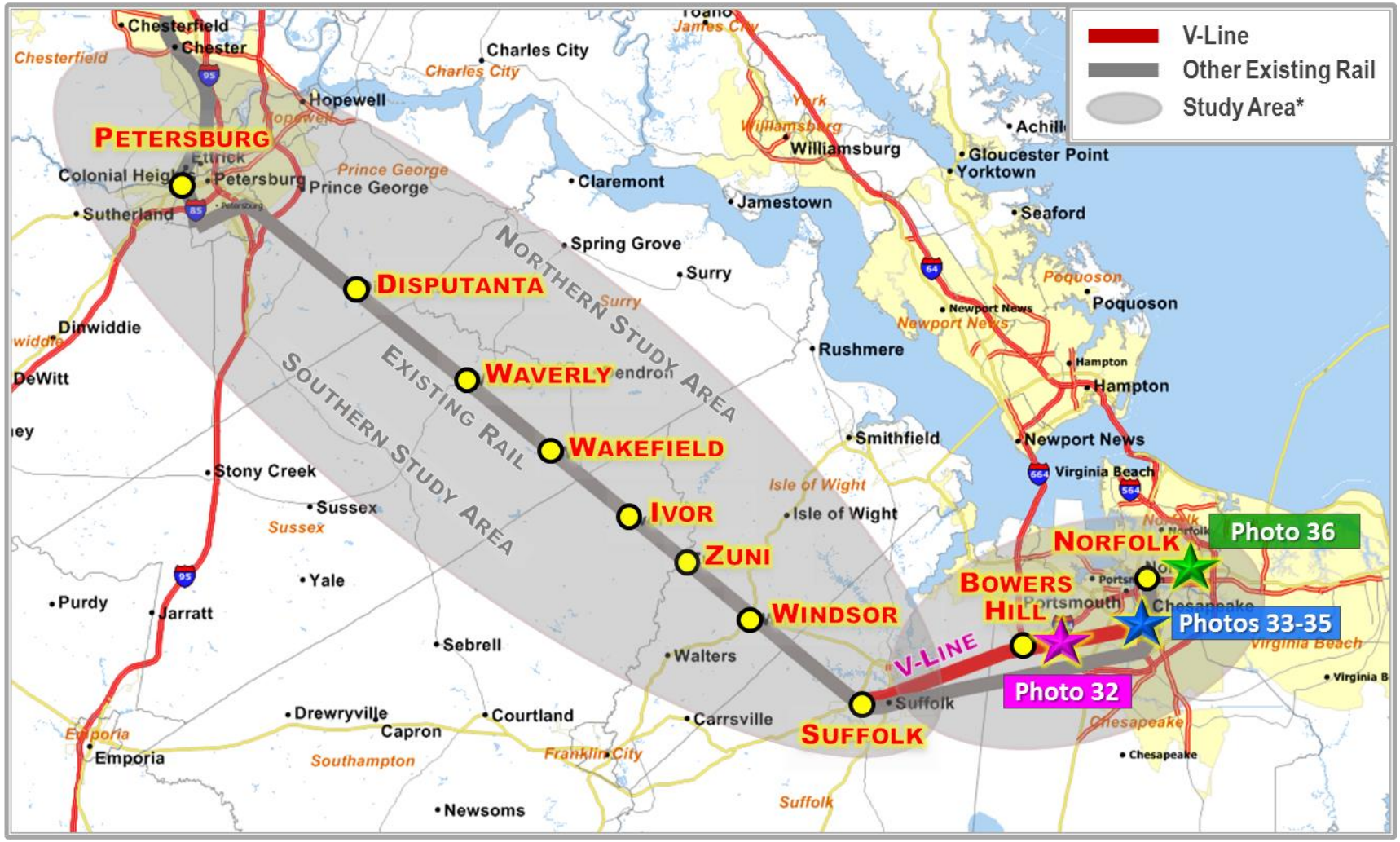
Exhibit 11: Existing V-line from Norfolk to Suffolk



*Alignment will not be determined until the Tier II Environmental Process is complete.

The following photos from 32 through 36 show abandoned tracks near I-64 and I-664, railroad crossings in Portsmouth, the humped railroad crossing at Chesapeake, tracks that requires roadwork and the improved Harbor Park station in Norfolk (See Exhibit 12 for location of these photos).

Exhibit 12: Photo Locations along Existing V-line from Norfolk to Suffolk



*Alignment will not be determined until the Tier II Environmental Process is complete.

Photo 32: Abandoned V-Line under the Bridge at Rotunda under I-664 and I-64.

Photo 33: Railroad crossing at Chapin Road in Portsmouth.

Photo 34: V-line joining the NS Main Line in South Norfolk, at the north end of Portlock Yard.

Photo 35: Humped Railroad Crossings at Park Avenue in Portsmouth.

Photo 36: Harbor Park Station in Norfolk.

APPENDIX F: TRANSPORTATION USE OF UTILITY CORRIDORS REFERENCE

High Voltage Transmission Line (HVTL) Right-of-Way Usage for Transportation Facilities

FEASIBILITY STUDY

FINAL REPORT

April, 2002

Maryland Department of Transportation

Office of Planning & Capital Programming

Acknowledgements:

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- ***Michael Bartholf - Deputy Administrator***
- ***Henry Kay - Director, Office of Planning***

Executive Summary

Executive Summary

Finding locations for new transportation corridors has grown more difficult as Maryland becomes more developed and available land in urbanized areas becomes scarce. Beginning with a proposal to the Montgomery County Council, the Maryland Department of Transportation agreed to conduct a study that would determine the feasibility of using existing high voltage transmission line (HVTL) corridors for transportation purposes as well. This involved locating a transportation facility in a corridor that often has very different characteristics from a traditional transportation alignment. Important considerations include the types of HVTL structures and corridor dimensions in comparison with various design requirements for different transportation modes. Because of the variability of these factors in Maryland, the study does not identify specific HVTL corridors for adaptation to transportation use. Rather, the study concludes with recommendations based upon general feasibility and lists the local conditions that would either favor or preclude joint use of HVTL corridors with transportation facilities.

In Maryland, five power companies transmit electricity on separate and individually maintained HVTL rights-of-way. The HVTL corridors vary in geographic location and transmission line voltage. The land within an HVTL corridor is either owned outright by the power company or purchased through an easement. Some common layouts of corridor width and structure location within the corridor are used as a starting point for further feasibility study. Footprints of towers on the ground as well as the necessary safety clearances, based on voltage and transportation type, reveal available portions of the corridor viable for transportation use.

Standards and guidelines for power structures vary by utility company. There is little precedent for guidelines regarding how power companies accommodate transportation along their rights-of-way or vice versa. The Maryland State Highway Administration (SHA) has a Utility Policy that outlines acceptable amounts of impact for HVTL structures in highway rights-of-way; however, it does not address sharing rights-of-way for long parallel sections. The necessary clearances and functionality stated in the Utility Policy would need to be achieved with no negative impact on the capability of the HVTL corridor as required by the power company's needs. Any improvements that would require modifications to the HVTL structures would require compensation to the Power Company and extensive modification could rapidly diminish any of the initial cost savings by using previously existing rights-of-way.

Design criteria for different modes of transportation are similarly documented. In addition to highway improvements, busways, light rail, sky train[1], and high speed rail (including Maglev technology) options are also considered along with each of their unique requirements. The possible combinations of these modes in several typical HVTL corridors are presented in the body of the report.

The Issues and Consequences chapter addresses the different design philosophies for HVTL and transportation corridors. HVTL corridors are not sensitive to elevation and can span many obstacles. Transportation corridors, however, need to have even grades and smooth transitions and often must go around major geographical obstructions. Maintenance of facilities is an issue

[1] A hybrid of light-rail and metro transit technology on elevated track and stations.

for both transportation facilities and utilities in the event of an incident or emergency. Safety concerns and sufficient clearance from the base of HVTL towers are also a major concern. Limiting the access to the towers causes an extra burden on the power company to maintain its property and could also preclude future expansion of the HVTL corridor to meet growing electrical demand. Costs increase and the ability to adapt transportation to an HVTL corridor decrease when the terrain is mountainous or there are multiple steep slopes. Examples of successful joint use occur in Louisiana where the land is flat and power companies benefit from having paved access to their structures. Within Maryland, there are numerous examples where HVTL and transportation share a corridor, but not over large distances where a previously existing HVTL corridor is adapted to transportation use.

The study reached five primary recommendations. The first recommendation is that only short segments of HVTL corridors should be utilized. Long distance use of HVTL corridors for transportation purposes is unlikely since a long HVTL corridor has a higher probability of rapid changes in direction or obstacles not easily negotiated by a transportation facility. A second recommendation is for low speed transportation options in HVTL corridors. Lowering operating speeds offers increased flexibility through less rigid design requirements and higher safety margins. Additionally, lower speed highway and transit modes have more tolerance for the grades and uneven ground that characterize an HVTL corridor in rolling terrain. A third recommendation calls for the use of guided transportation vehicles. Guided technology offers a higher safety margin and vehicles can operate closer to structures, thus better utilizing narrow HVTL corridors. A fourth recommendation is for a wide HVTL corridor on level terrain. The width of HVTL corridors analyzed within this report generally varied from 150 feet to 250 feet. Corridors less than 250 feet, afford little room for roads or rail to negotiate obstacles. Level terrain is important, as transportation facilities often require cuts or fills through rolling terrain, which may be incompatible in an HVTL and require costly retrofits. The fifth and final recommendation is for HVTL corridors with steel poles supporting the transmission wires. Steel poles have a smaller footprint on the ground and can offer increased buffer space between the base of the structure and the transportation facility. The recommendations are general in nature further study would be required for a particular corridor within Maryland. Even after a candidate HVTL corridor has been identified, the report emphasizes that only with an appropriate transportation mode and under a special set of circumstances would joint use likely be feasible.

In summary, the overall recommendations of this study for those conditions that would best support the implementation of a transportation facility within an existing HVTL corridor are as follows:

- Utilization of short HVTL corridor segments instead of long segments
- Lower speed
- Guided transportation systems
- Wider corridors with level terrain
- Steel poles used as HVTL structures

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I. Introduction

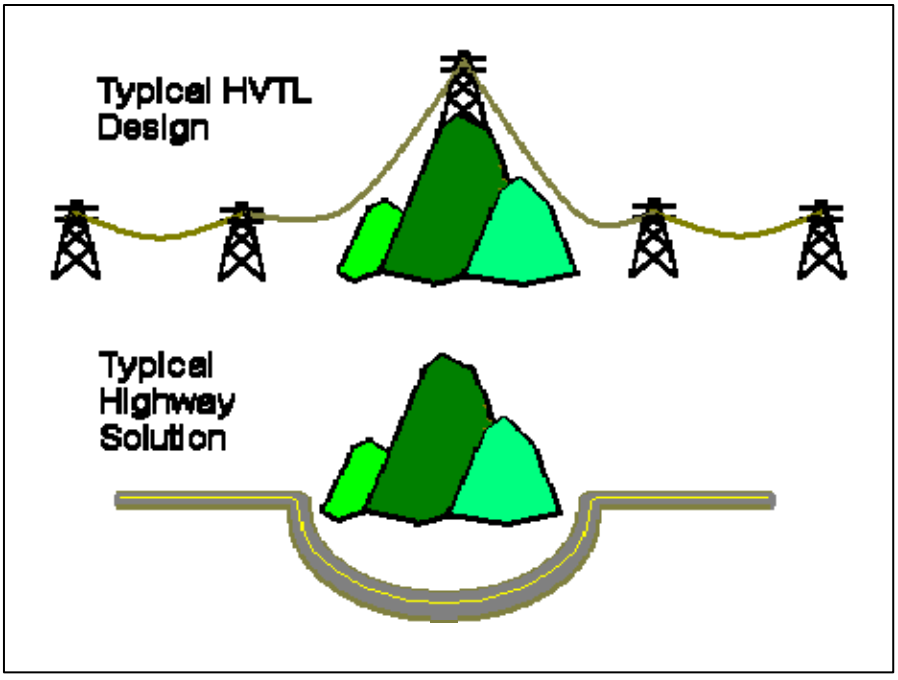
I. Introduction

Introduction / Project Purpose

As Maryland becomes more urbanized, there is a need to identify new strategies for locating transportation facilities. The traditional approach of purchasing an exclusive use right-of-way has become cost prohibitive. As a result, the Maryland Department of Transportation (MDOT) is interested in alternative ways to locate transportation facilities when the cost and availability of land would otherwise prevent the outright acquisition of a new transportation right-of-way. The goal of this study is to analyze the feasibility of using HVTL rights-of-way for transportation purposes while maintaining the utility companies' ability to maintain a safe, reliable, and economic electric supply. This general feasibility approach involves examining the different design philosophies of HVTL and transportation corridors and determining the conditions that would favor joint use.

The selection of transportation and HVTL corridors is based upon many factors. Transportation corridors are very sensitive to elevation changes and every effort is made to minimize grades. HVTL corridors use straight alignments where possible and are much less dependent on elevation differences. An HVTL corridor also has the ability to span certain obstacles or obstructions, while a transportation corridor often needs to go around such impediments (see Figure I-1). Across Maryland, there are many different HVTL structure configurations, each based upon specific conditions. The line voltage, number of circuits, available span lengths, and number of angles in the line route all determine types of poles and towers and their placement within the corridor. Transportation facility design is impacted by many factors including design speed, method of vehicle guidance, vehicle performance, and safety. This variability requires a broad examination of transportation requirements and HVTL corridor conditions across Maryland.

Figure I-1 - Differences in HVTL and Highway Design Philosophy



This study was initiated by MDOT subsequent to interest outlined by the Montgomery County Council, based upon a proposal submitted by Mr. Byrne Kelly, the principal of a Takoma Park planning and landscape architecture firm. Study recommendations identify the combinations of HVTL corridors and transportation modes that are most compatible and the circumstances that make the economic and environmental benefits of using HVTL rights-of-way superior to other rights-of-way for transportation purposes.

HVTL corridors are networked throughout the State of Maryland. The corridors are managed and maintained under the jurisdiction of five separate utility companies. A 'high voltage' transmission line is defined as one with an electrical phase-to-phase voltage in excess of 69,000 volts (69kv) or higher. The lines are located primarily above ground and supported by various types of tower structures. The corridors range in right-of-way width from 50 to 500 feet, with overall corridor width dependent upon the voltage of the electricity in the line. Higher voltages require more physical separation both within and along the corridor for safety considerations and this may necessitate larger corridor widths. The utility company may either own the corridor right-of-way in fee simple or be granted easements from the property owners in which to place their lines and structures. Likewise, higher voltages require more physical separation both within and along the corridor for safety considerations and this necessitates larger corridor widths.

The original intention of the study was to look at several specific corridors within Maryland and to recommend which corridors may be viable for transportation use. It was soon realized, however, that it would be difficult to base corridor specific feasibility of joint HVTL and transportation on only a few examples. Other concerns that arose included heightened public sensitivity towards the study of specific corridors, possibly raising public concerns and creating perceptions that transportation facilities were indeed being planned and designed within these corridors. As a result, the study was refined to look at general feasibility across the State. First, the study investigated the characteristics of various HVTL corridors in Maryland. The second phase included an analysis of various transportation options that could potentially utilize an HVTL right-of-way. Following these two steps, the study identified issues and consequences of for combined usage through discussions with stakeholders. Finally, the study concluded with recommendations concerning general feasibility of various transportation options in different corridors. The recommendations steer any future study of corridor specific implementation to the most promising candidates of transportation options based upon the HVTL corridor conditions. Throughout the study, national and statewide examples were gathered to represent some of the various possibilities for joint use, highlighting their practical benefits and issues.

Scope Summary

To prepare this feasibility study, the following activities were undertaken:

- Gather information and create a database of local and national examples of transportation facilities that were either built within HVTL corridors or contain HVTL issues, such as crossings, easements, etc.
- Initiate a Technical Advisory Committee, comprised of representatives from the statewide power companies and the transportation modal administrations, to serve as a 'two-way' sounding board throughout the study.
- Develop typical sections for several transportation modes and analyze the impact of locating these sections within generic HVTL corridors.
- Develop a comprehensive list of the issues associated with using HVTL rights-of-way for transportation use.

- Determine the anticipated difficulties that will arise through constructability concerns, applying to both the utility and transportation infrastructure.
- Summarize the above-mentioned tasks and key project activities and offer recommendations for possible transportation facility design concepts for different HVTL corridor types, geographical regions, and power company jurisdictions within a final report.

In developing typical sections, the study analyzed HVTL corridors of 150 and 250-foot right-of-way width, which included standard placements of towers within each type of corridor. To further reduce the complexity and number of typical sections to generate, transportation design criteria were established from the onset of the study. Design criteria identified the safety and performance requirements of certain transportation options that must be satisfied within the limits of an existing HVTL right-of-way.

This report can be used as a tool during the alternatives development phase of a transportation planning project and aid in determining whether or not to consider an HVTL corridor as a viable alternative for study through the project planning development process.

II. Statewide HVTL Characteristics

II. Statewide HVTL Characteristics

Maryland Power Companies

The electrical power transmission lines, steel structure and corridors dispersed throughout Maryland are owned, designed and maintained by five power companies, all with specific jurisdictions (see *Figure II-1*). The companies are listed and briefly described below:

- ***Allegheny Power (The Potomac Edison Company)*** – Within Maryland, Allegheny Power serves Maryland's westernmost counties and small portions of Montgomery, Howard and Carroll counties. Its jurisdiction also extends into Pennsylvania, West Virginia, Virginia and Ohio.

- ***Baltimore Gas and Electric (BGE)*** - Includes all or part of the nine counties within central Maryland, including Baltimore City.

- ***Conectiv*** – Serves all the Maryland Eastern Shore counties, Cecil County and part of Harford County, all of Delaware and the southern portion of New Jersey.

- ***Potomac Electric Power Company (PEPCO)*** – Serves the majority of Prince George's and Montgomery counties and the entire District of Columbia.

- ***Southern Maryland Electric Cooperative (SMECO)*** - Serves Charles, St. Mary's and Calvert (except the northeastern tip) Counties, and the southernmost portion of Prince George's County.

Representatives from the five power companies have been involved with the study since its inception in 2001. They met five times as part of the Technical Advisory Committee (TAC) and contributed ideas and voiced comments and concerns throughout the study. Other members of the TAC included utility experts from SHA's Offices of Construction and Highway Development, a representative from SHA's Office of Planning and Preliminary Engineering, representatives from the Maryland Transit Administration (MTA), and representatives from MDOT's Office of Planning and Capital Programming.

The TAC meetings were quite helpful and provided the groundwork for this report.

Typical Corridors

Each power company serves a different geographic region and coverage area throughout Maryland. The result is that each company's HVTL corridor characteristics vary. The density of the power company's network affects corridors when customers are located at large distances from generating facilities. For efficient transmission, this necessitates longer HVTL corridors that require increased right-of-way width for safety clearances. Typically, corridor width increases as the transmission line voltage increases. The final step in delivering electricity to customers involves localized and low voltage power distribution lines to residential or retail/business communities. These lines, with their lower voltage and safety requirements, often utilize an existing transportation right-of-way and run along existing arterial roadways and collector streets. See the Transportation Options section for typical section sketches.

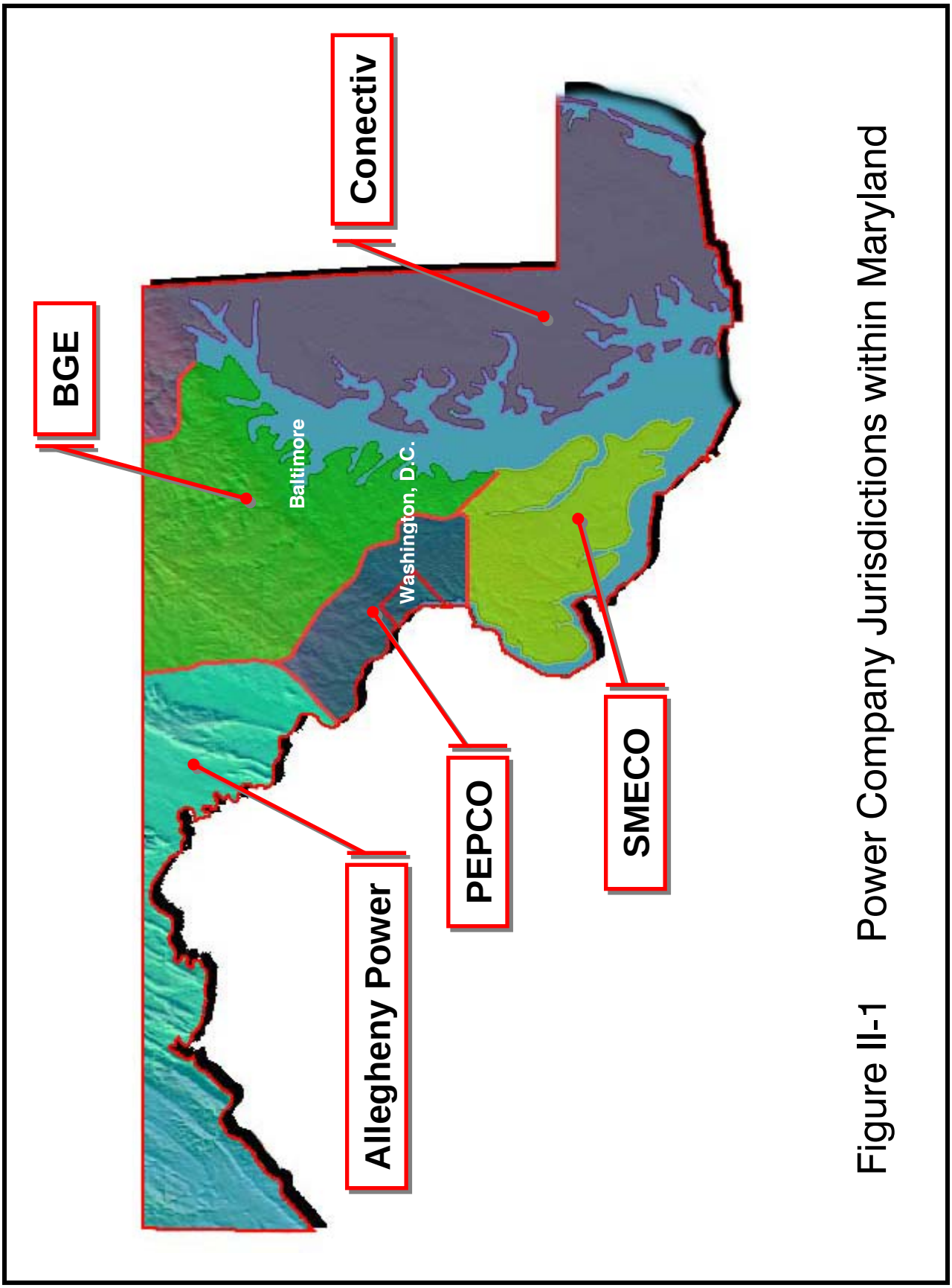


Figure II-1 Power Company Jurisdictions within Maryland

the wires that must be maintained. Also, it usually means the HVTL structures must be built stronger to carry the increased weight of lines carrying the higher voltage.

Other factors affecting HVTL structures include the span lengths, the available land, and the number of angles in the transmission line route. The severity of the angle is a very important criterion in transmission line design. It takes a stronger or more stable structure to support the wires turning an angle versus a tangent section. *Photo 1* shows a pole supporting wires turning an angle. Its construction is much sturdier than the pole shown in *Photo 2*, which is along a straight segment.

The strength to support heavier wires and span large distances dictate that HVTL structures be of substantial construction. For these reasons, usually only the lighter, lower voltage lines (typically less than 100 kv) are considered for wood structures. In the past, the only choice other then wood poles was the steel (lattice) tower configuration. Beginning about 40 years ago, tubular steel poles were manufactured to replace steel (lattice) towers. These steel poles provided sufficient strength while occupying less space at the ground level. Initially, steel poles were very expensive and used sparingly, but improved manufacturing and design processes have now made this type of structure more economical and its use has increased throughout the State.

Figures II-2 and II-3 are detailed sketches of a typical steel pole structure with 230kv dual circuits. *Figure II-2* shows the dimensions for a pole within a tangent section of the corridor. *Figure II-3* shows the dimensions of a pole used to support wires with medium and heavy angles.

Photo 1 - Large Steel Pole / Tower

This pole is 4 feet in diameter and is designed to withstand higher loads since the transmission lines and conductors form an angle. The voltage carried by this pole is 115 kv.

Photo 2 - Steel Pole in Tangent Section

The steel poles carrying 115kv transmission lines shown here are along the edge of the public right-of-way for MD 3, near Crofton, Maryland. The pole diameter is 3 feet.

Lattice towers are the most common structures found in Maryland's HVTL corridors. As shown in *Photos 3 and 4*, lattice towers have a much larger footprint than steel poles. This is due to the lattice tower's expanded base. The size of the structure footprint is important in determining the viability of implementing a transportation facility within the HVTL corridor right-of-way.

The base of a lattice tower is generally square and ranges from 16 feet per side to over 40 feet per side. The size depends on the height of the tower (the higher the tower, the wider the base) and the loading on the tower from the weight of transmission lines.

Photo 3 - Dual Lattice Tower Configuration

This photo shows the dual lattice tower configuration, one of the most common HVTL corridor configurations in Maryland. Figure II-4 describes the dimensions and spacing at this location.

Photo 4 – Single Lattice Tower Configuration

This is an example of a single lattice tower configuration. It has a narrower corridor due to the single row of towers.

The exact shape and placement of transmission wires can vary among lattice towers. This depends on the amount of support needed for the particular transmission wire circuitry. As evidenced by *Photo 5*, this tower was designed to handle only one horizontal row of transmission wires.

Photo 5 – 'Short and Wide' Lattice Tower

This corridor carries 230kv wires within BGE's jurisdiction. The base members of these structures are similar to those of the 'common' lattice towers, but the difference is that this tower widens at the top.

When the lattice towers need to be upgraded to handle higher loads (more circuits, higher voltage, etc.), they are often replaced with steel poles. Eventually there will be more steel poles than lattice towers throughout Maryland, especially if corridors are upgraded to handle 500kv transmission lines. Currently, there are very few 500kv HVTLs in Maryland, which typically connect power plants to main substations.

Photo 6 - Steel Poles Supporting 500kvWires

Photo 6 shows typical steel pole structures within 500kv corridors.

Photo 7 - 500kv Corridor

Photo 7 shows the same corridor, as in Photo 6, crossing a limited access highway (MD 3 in Crofton).

Photo 8 – Multiple Steel Poles

The steel poles in this photo need to provide extra support for the 500kv transmission wires due to the angle in the corridor. Absent any angles, fewer poles would be needed.

Standards and Guidelines

Each power company has their own general design standards and guidelines that are based in part on the National Electrical Safety Code (NESC). The purpose of the NESC is to provide the minimum accepted standards and guidelines for the practical safeguarding of persons during the installation, operation, and maintenance of electric supply and communication lines and associated equipment. Naturally, these safeguards would need to be extended to the vehicles using any transportation facilities placed in the vicinity of the HVTLs.

The NESC contains the basic provisions that are considered necessary for the safety of employees and the public under specified conditions. The NESC is not intended to be used as a design specification or an instruction manual. Individual power companies develop their own design standards and guidelines.

Table II-1 on the following page summarizes each power company's general guidelines for HVTL spacing and clearance requirements between transmission line structures and transportation facilities. NESC guidelines are also shown for comparison reasons. The horizontal clearances between the structure and the roadway facilities are generally determined on a case-by-case basis, depending on the transportation facility's design speed, types of protection barriers, and MDOT's fixed object safety standards. The vertical clearance categories are determined by the transmission line voltages.

See *Figure II-5* for a three-dimensional visual representation of the clearance locations.

Table II-1 - Safety Spacing/Clearance Guidelines in Maryland

	Allegheny Power	BGE	Conectiv	PEPCO	SMECO	NESC minimums
Horizontal Clearance from tower base to the edge of hwy. shoulder or rail track	15’	30’	25’	35’ preferred	MDOT req.+ barrier	Not specified
Horizontal Clearance between the vertical projection of the overhead conductor to the edge of hwy. shoulder or rail track	Not given	Not given	Not given	10’	Not given	8.7’
Horizontal Clearance from tower base to excavation work (blasting, grading, etc.)	Not given	40’	25’	Not given	Not given	Not given
Vertical Clearance between 115kv – 138kv conductor wires to the highway surface	25’	Exceed NESC	Exceed NESC	Not given	Exceed NESC	20.6’[1]
Vertical Clearance between 230kv conductor wires to the highway surface	27’	Exceed NESC	Exceed NESC	35’	Exceed NESC	22.4’[1]
Vertical Clearance between 500kv conductor wires to the highway surface	35’	Exceed NESC	Exceed NESC	Not given	Exceed NESC	27.9’[2]
Vertical Clearance between 115kv – 138kv conductor wires to the rail track surface	33’	Exceed NESC	Exceed NESC	Not given	Exceed NESC	28.6’[1]
Vertical Clearance between 230kv conductor wires to the rail track surface	35’	Exceed NESC	Exceed NESC	35’	Exceed NESC	30.4’[1]
Vertical Clearance between 500kv conductor wires to the rail track surface	43’	Exceed NESC	Exceed NESC	Not given	Exceed NESC	35.9’[2]

[1]The NESC computes minimum vertical clearances by adding 0.4 inches of clearance for each kilovolt over 22kv, up to 470kv. This spacing is added to the overall minimum clearance of 18.5 feet over highways, and 26.5 feet for rail tracks. For example, to calculate the additional clearance above 18.5 feet for a 230kv line spanning a highway, multiply the 230 kv * 105% (to obtain maximum operating voltage); then 242kv * √3 (this give the voltage to ground), then you would multiply (140kv-22kv) * (0.4”) * (1 foot/12”).

[2]The formula for determining additional spacing for transmission lines above 470kvkv is more complicated than for lines less than 470kv.

Note: Transmission wires naturally sag between tower connections due to the span length between towers and the downward force of gravity. However, the sag distance (drop in elevation at the low point of the wire) can vary depending on a number of factors. They include the conductor wire material, conductor wire tension, current flow, temperature, and precipitation (especially ice). For spans upwards of 1000 feet, the sag increase can be as much as 6.5 feet closer to the ground.

III. Transportation Options

III. Transportation Options

Overview

Transportation options or typical sections were developed as part of this study with the purpose of demonstrating the feasibility of implementation within existing HVTL corridors, or incorporated within the design of new HVTL corridors. The study team was unable to evaluate all possible scenarios due to almost unlimited number of typical sections that could be applied, particularly since the HVTL corridor vary tremendously. Modal options include heavy rail and light rail transit lines, general-purpose or managed highway lanes, and bus rapid transitways (BRT).

In developing these transportation options, the guidelines set forth by the five power companies and the National Electrical Safety Code (NESC) were important requirements. The power companies currently work with the Department of Transportation while designing their infrastructure improvements within or near transportation corridors. The power companys' designs must gain the approval of the administration, which owns rights to the transportation corridor or facility before any implementation can take place. This often requires complicated agreements for design, maintenance, and operations.

The next section discusses an example policy set forth by the Maryland State Highway Administration (SHA), regarding guidelines for utility lines adjacent to or crossing state highway facilities.

Maryland Utility Policy

The Maryland Department of Transportation, State Highway Administration's Utility Policy (SHA Utility Policy) regulates utility occupancy in SHA highway rights-of-way. This policy was developed in 1989, following a declaration by the Federal Highway Administration (FHWA) that granted approval authority of longitudinal occupancy of utility installations within highway rights-of-way to the state governments.

Potential impacts of HVTL installations upon the functions of a highway include the disruption of traffic flow, safety, and provisions for maintenance and future expansion of the highway. These impacts are addressed in several broad categories of regulation contained in the SHA Utility Policy, including:

- Obstruction of, or interference to, the operation of a State highway.
- Maintaining State highway safety during access and maintenance of utility installations.
- Utility design specifications and minimum construction standards within State highway right-of-way.
- Cost responsibility for any required modifications or relocation of utility facilities as required by State highway regulations.

Of most concern to utility companies currently enjoying unrestricted access to their facilities are the following safety precautions set forth by the SHA Utility Policy[1]:

[1] SHA Utility Policy, 1989. Page 2-4.

- Utilities will take precautions to protect the traveling public. No lane closures during the peak hours will be allowed. In some cases, it may be necessary to perform the work during off peak times or at night.
- Private automobiles and non-essential construction vehicles shall not be parked on SHA rights-of-way.
- Mud and debris tracked or spilled on the roadway shall be removed promptly.
- Appropriate protective measures, approved by the SHA, including warning signs and barricades, may be necessary around excavations or construction sites.

In general, the SHA Utility Policy states that longitudinal utility lines, whether above ground or underground, are not permitted within the right-of-way of existing highways. Wireless telecommunication installations are permissible within expressway rights-of-way and the requirements governing this use could also apply to highway locations around pre-existing HVTL structures. The priority order of utility structure location within expressway rights-of-way is stated as follows:

1) Vehicle access to the site can be obtained from outside the through roadway and connecting ramps.
2) Within interchanges, vehicle access can be obtained from the right hand side of the diagonal ramps.
3) Within interchanges, vehicle access can be obtained from the left hand side of the diagonal ramps.
4) Vehicle access can be obtained from the outside shoulder of the mainline.
5) Vehicle access can be obtained from the inside shoulder (median side) of the mainline.

Arterial and collector highways do not require such strict location criteria. In general, a lower design speed of the highway allows for more flexibility in utility structure placement and affords an extra margin of safety that helps to reduce some concerns regarding access to, and the maintenance of, the structure itself.

Federal Policy

Federal-aid policy states that a lack of sufficient right-of-way width to accommodate utilities outside the roadside border, in and of itself, is not a valid reason to preclude highway facilities and utility structures to coexist. In fact, the policy only presents guidelines rather than a fixed requirement for horizontal separation. Vertical separation is explicitly governed by State policy. However, these minimum clearances are less than the NESC and power companies' guidelines. For longitudinal lines, the following minimums must be maintained:

Table III-1 - Vertical Clearances (SHA)

Minimum Vertical Clearance (feet)	**Transmission Lines**
18	Guy wires and secondary power wires below 750V.
20	750V – 22kv
21	22kv – 50kv
21 feet plus 0.4" per kv in excess of 50kv	50kv – 470kv

When the state agency lacks authority over the right-of-way, Federal policy dictates that an agreement must be reached with the utility such that the degree of protection to the highway is at least equal to the protection provided by the State agency's utility accommodation policy. In this case, SHA requirements must be upheld in any agreement reached with a utility company for the use of utility right-of-way for highway purposes. The specifics of these requirements can be referenced in the SHA Utility Policy[2].

Federal participation for funding the replacement and modification costs incurred by the utility company is available under certain conditions. Replacement right-of-way costs may be provided when the portion of the utility's existing right-of-way is transferred to the State Highway Administration (SHA) at no cost to the project. When relocation work is shared between SHA and the utility company, a written agreement stating the shared responsibilities of each entity is required for Federal-aid. The provisions of the FHWA's regulations covering reimbursement for utility work is for actual costs incurred to functionally restore a utility's existing operating facilities prior to the commencement of the highway project. The utility's financial and productive situation is to be maintained as if the highway project had not occurred. Where possible, this would not require construction of a replica facility, rather that the utility service is to be made whole by restoring the existing functions of the impacted facilities.

Use and occupancy agreements are used to establish the terms and conditions under which utility and highway installations co-exist. Federal-aid policy[3] stipulates what such an agreement must include, with the following being critical to this study:

- The State agency standards for accommodating utilities. Since all of the standards will not be applicable to each individual utility installation, the agreement at a minimum must describe the requirements for location, construction, protection of traffic, maintenance, access restriction, and any special conditions applicable to each installation.
- The extent of liability and responsibilities associated with future adjustment of the utilities to accommodate highway improvements.
- The action to be taken in case of noncompliance with the requirements.

[2] Maryland State Highway Administration, Utility Policy
[3] Federal-Aid Policy Guide, 23 CFR 645 A, Sec. 645.213

Transportation Design Criteria

Introduction

The design criteria for any transportation facility will ultimately determine the feasibility of its use in an HVTL corridor. The criteria determine the accuracy and the specification of the design and establishes the physical constraints that must be applied. Depending on the type of transportation facility or mode certain guidelines apply. Examples include the size and characteristics of the design vehicle, method of operation, the intended level of service, as well as the number of people expected to use a transportation facility. "Design criteria" are more specific. Some examples include the lane or track width, grades, sidewalk width, maximum and minimum superelevation (banking), maximum travel speed, maximum structure width or span, and horizontal and vertical clearances. Environmental considerations are vital since permits are needed and environmental documents must be approved before a facility is ultimately constructed. Also, the designs must be reasonable and practical from an economic standpoint.

Design Criteria for Highways

AASHTO Design Standards

The American Association of State Highway and Transportation Officials (AASHTO) publishes a design criteria standards manual, entitled: 'A Policy on Geometric Design of Highways and Streets', approximately every five years. It aids state highway administrations in the design of their facilities. The following is a list of the primary guidelines that were used to develop the highway options for this study (assuming a fully access-controlled, 4-lane highway).

- The ideal 4-lane highway consists of two, 12-foot traffic lanes in each direction, separated by a wide grassy median. If a wide median (54 feet or wider) is not feasible, then roadside barriers need to be implemented. AASHTO guidelines state that an 8-foot wide outside shoulder is the minimum, but it ultimately depends on the anticipated amount of traffic. Also, in some cases an 11-foot wide travel lane can be used, but the percent of truck usage has to be low.
- Design speed for urban and rural expressways vary from 40 mph to 70 mph, respectively. Terrain has a major influence on the selection of a design speed. This study uses a 'rolling' terrain with a design speed of 60 mph.
- With a 60 mph design speed, the minimum radius of horizontal curvature is approximately 1,350 feet. Therefore, if a HVTL corridor makes an abrupt turn, adjacent rights-of-way may need to be purchased to 'round-out' the curve.
- Grades depend on the type of terrain as well as the type of highway vehicle. For a 60 mph highway, a 4% maximum grade is used for rolling terrain, and up to 6% for freeways in mountainous terrain. A maximum grade of 5% is used in this study.
- A 16-foot vertical clearance should be provided for any bridge structure spanning the entire roadway width. Some additional clearance has to be taken into consideration for future resurfacing of the under passing roadway.

Design Criteria for Transit

Light Rail

The design speed of a light rail system depends on the type of vehicle and the type of terrain. It is normal for a light rail vehicle to operate between 40 and 50 mph along restricted access rights-of-way. The horizontal curves can be tighter than that required for a 60 mph freeway because the operating speed is controlled and can be lowered to a safe speed while maneuvering curves. The maximum grade for a long, sustained segment is 4%, but up to 6% for short segments of less than 2,500 feet between the crests and sags. At light rail stations, grades can vary from a desirable 0.5% to a maximum of 2.5%, but this is also dependent on the type of rail vehicle. Track spacing for two-way service varies based on vehicle specification, superelevation, and terrain. Using this standard, minimum track spacing of 12.25 feet center to center would be acceptable. A more desirable track spacing of 14 feet center to center would be used. Vertical clearance depends on the type of vehicle as well. Light rail vehicles receiving power from overhead wires require a clearance of 15 feet from the top of the rail to the overhead wire.

Busways

The design guidelines for busways are similar to light rail. However, busways can accommodate steeper grades and tighter turns. For this report, we will group them together. Of note, is that busways are flexible and can be either exclusive alignments or shared with highways.

High Speed Rail / Maglev

The design constraints are much more stringent for high-speed rail options. Included in this category is Amtrak and local commuter rail services (MARC, etc.), SkyTrain and Magnetic Levitation (Maglev).

Basic design requirements for high-speed rail systems are listed below:

- Speed – The design speed of high speed rail lines primarily depend on the type of vehicle that will be utilizing the tracks. For many existing commuter rail lines, the tracks are shared with freight trains and in most cases were initially designed for the lower speeds associated with the freight lines, which would mean tighter horizontal curves. Even though commuter train systems (Amtrak, MARC, etc.) are capable of speeds in excess of 100 mph, they would be limited to the maximum design speed used when the tracks were initially built. The design speed for commuter rail using new tracks implemented within HVTL corridor rights-of-way would depend on the lengths of the tangent sections and the severity of the corridor angles. The scenario would change quite drastically though, if a Maglev line were to be implemented, with speeds reaching 240 mph.
- The minimum horizontal curve radii increases almost exponentially as the design speed of the facility increases. Therefore, for tracks that are designed to carry a Maglev train designed for 240 mph, it may take over a mile to complete a single curve.
- Grades – Similar to the speed, the grade depends on the type of vehicle that will be used. Generally, a maximum grade is about to 2% to maintain speeds, but there are exceptions. In fact, the Maglev could travel on a maximum 10% grade. Other heavy rail systems, such as the Washington Area Metropolitan Transit Authority's Metrorail line, have segments with grades as high as 4.5% where operating speeds must be lowered. At

station locations, the maximum grades are reduced to a desirable grade of 0.35%. This would be the same for surface, underground and raised platforms station.

- Track Spacing – The minimum track spacing between the centerlines of parallel tracks is 14 feet, but can be up to 15 feet due to the size of rail cars used.
- Vertical Clearance - Vertical clearance depends on the type of structure, and the type of vehicle. Vertical clearance is usually measured from the top of a rail to the bottom of a structure. A preferable minimum vertical clearance for a heavy rail corridor is usually 22 feet. In some cases, such as the Washington Area Metrorail (a fixed structure in an open environment), the minimum clearance is as little as 13 feet. Vehicles that require overhead contact wiring would require additional vertical clearance.

SkyTrain is a rail system built primarily on an elevated guideway consisting of concrete pylons. It has been in use in other countries besides the United States for over 20 years. SkyTrain is faster and more environmentally safe than most existing rail lines since it runs exclusively on electricity, therefore producing no harmful emissions. Even though SkyTrain systems travel at speeds in excess of 50 mph, they are relatively quiet compared to other rail systems, and much quieter than a diesel truck. As an automated system, SkyTrain runs more frequently and efficiently than other transit systems, with as little as a 75-second gap separating trains. Because it operates along a dedicated guideway separate from the road system, SkyTrain does not interfere with highway traffic operations. The cost to design and construct a SkyTrain system is between $30 million and $40 million per-mile, dependent upon a number of factors. This cost incorporates approximately $20 million per-mile of concrete elevated guideway, $5 million to $7.5 million per station, various “cut and cover” tunnel and related structures along the line, and other miscellaneous items.

Maglev is a newer technology incorporating an electromagnetic, non-contact levitation and propulsion system that is an alternative to traditional wheel-on-rail trains with a system that lifts, guides and propels the vehicle along a guideway at speeds up to 240 mph. Still in its planning stages in the Baltimore/Washington corridor, it could be implemented within the next 10 to 12 years. Test tracks have been built in Europe and the results are positive thus far. The cost to design and construct a Maglev system is between $70 million and $80 million per-mile, incorporating the same elements and contingencies as the SkyTrain system.

Hypothetical Corridor(s)

Based on the above criteria, typical sections were developed for a variety of potential HVTL corridor configurations. The purpose of this was to create a template to evaluate the typical section through a hypothetical HVTL corridor, consisting of the common tower configurations and corridor widths found in Maryland. The results help the study team determine what impacts the transportation typical section would cause to the HVTL infrastructure and what cost might be necessary to mitigate these impacts.

Two HVTL right-of-way widths were analyzed; 150 feet and 250 feet. Each corridor width was analyzed along an actual 5-mile tangent section that exists within Maryland. Several tower configurations were hypothetically considered within each corridor width with upwards of 3 large steel poles and two wooden poles per corridor. This would serve to represent a future ‘full build-out’ scenario, or most highly constrained HVTL corridor.

Topographically, these corridor(s) represent the terrain found in a typical HVTL corridor throughout almost all counties west of the Chesapeake Bay. Several of the towers are placed on hills while the transmission wires span ravines and valleys. To stay within the guidelines set forth by both AASHTO and the SHA / MTA, it was realized that several large cuts and/or fills would be required, along with retaining walls to protect the foundations of the towers. Otherwise, to move one tower is to move or affect the system of towers. Vertical profiles were created under each scenario, noting that the grade requirements for highways, light-rail systems and BRT were all quite similar, but highly constrained for the heavy rail option.

Typical Sections

The following series of figures (*Figures III-1 through III-7A*) represents the various combinations of typical sections with corresponding 'elevation' sketches illustrating the projected clearance distances. Note that several other typical sections were developed and initially analyzed, but were found to be less desirable than the sections evaluated here. Some proved impractical while others violated the standards and policy guidelines for highway and HVTL use (these typical section figures can be found in *Appendix B*). An explanation of the reasons why those typical sections were not carried for further analysis is also in *Appendix B*.

Ownership of the corridors varies by power company. PEPCO is the only company in Maryland that purchased and continues to own the land rights (with a few exceptions) for their HVTL corridors. BGE owns roughly half of their HVTL corridor rights-of-way. SMECO, Allegheny Power and Conectiv have limited land rights through easements from private property owners. Essentially, the amount of land purchased or obtained through easements depends on the land area needed to construct, operate, maintain, and expand the HVTL corridor.

ALLEGHENY POWER

Allegheny Power's typical HVTL corridors vary dependent upon the transmission voltage. For 500kv corridors, the right-of-way widths are typically 200 feet and the primary structures used are steel (lattice) towers. For 230kv corridors, the right-of-way width is usually 125 feet and the structures can be steel lattice towers, steel poles, or multiple wood 'H' frame structures. For 138kv corridors, the right-of-way width is usually 100 feet, and the steel structures can be steel poles, steel towers, or multiple wood 'H' frame structures.

BGE

There are several types of HVTL corridors within BGE's jurisdiction. The corridors vary in width and contain several different types of structures. Voltages carried in the various corridors include 115kv, 230kv and 500kv. BGE has examples of shared use corridors in its system, including shared right-of-way with Amtrak along the Northeast Corridor and a short corridor shared with the Baltimore Light Rail Transit (LRT).

CONECTIV

Conectiv's corridor easements are typically 150 feet wide and have long tangent segments due to the flat topography and a larger percentage of available land, primarily with agricultural land-uses. Most corridors have at least one wood pole H-frame line in the center of the easement.

PEPCO

PEPCO's 230kv corridors are typically 250 feet wide. The width of 500kv corridors varies. Most of the corridors have dual steel (lattice) towers. PEPCO's ultimate build-out scenario for 230kv corridors is a triple steel pole configuration with the third line of structures constructed along the centerline of the corridor. The corridors also have lower voltage transmission lines, primarily wooden poles carrying 69kv lines, near the edge of the corridor. Due to PEPCO's high service demand within the Washington Metropolitan region, many of the existing 230kv corridors already include one or more 69kv lines along the edge of the corridor.

SMECO

SMECO's only HVTL corridor is a 230kv line with an average right-of-way width of 150 feet. Within this corridor, there is a single line of steel poles down the centerline of the corridor, with wooden poles carrying lower voltages approximately 25 feet from the corridor edge. The opposite side of the corridor will be used for future expansion needs, possibly dualization of the wooden poles.

Typical Tower Structures

Statewide, there are various structure configurations for HVTL corridors. Different utilities use different configurations depending on the specific conditions in the corridors. The differences are due to factors such as line voltage, the number of circuits, the current capacity required and the line route. In general terms, the higher the voltage, the larger the required safety area surrounding

IV. Issues and Consequences

IV. Issues and Consequences

Types of Issues

The study identifies several issues and concerns related to the utilization of HVTL rights-of-way for transportation facilities, especially compared to potential rights-of-way in undisturbed areas. Utility company representatives and highway officials have also identified issues and concerns. The issues represent the specific interests of the stakeholders but can also have a broader effect upon the likelihood of an HVTL corridor being selected for use as a transportation corridor. These issues may be an advantage, a disadvantage, or even both, dependent upon the stakeholder. A generalized collection of issues have been prepared and their effects, based upon the individual stakeholders, summarized below:

Access Issues:

- **HVTL rights-of-way generally do not run in areas of high transportation demand.** Most HVTL corridors are in rural or low-density areas. The areas where HVTL corridors exist generally do not generate travel demand sufficient to support transit service or a highway. The corridor may not easily connect with the existing transportation network. And due to safety concerns associated with development near HVTLs, it could be difficult to target growth to the corridor.

- **Easier access for maintenance equipment to towers and lines.** If a transportation facility is in the HVTL corridor, it should facilitate the power company's ability to bring maintenance workers and equipment from its storage facility to the structures and lines. Many HVTL corridors have rugged terrain and the addition of a graded, paved road would facilitate access. Having a better and quicker means of access would also be beneficial in emergencies.

- **Power line maintenance could become less time efficient.** In many cases today, rights-of-way are already accessible for the power companies' maintenance needs, including the use of access agreements with adjacent property owners. A paved corridor could result in quicker access times, but the time savings could be reduced because of the additional time needed to restrict and control traffic so that maintenance activities can be performed in a safe manner for workers and the general public.

- **Traffic Impacts.** Maintenance and repair of the HVTL and associated structures could impact traffic flow on the transportation facility.

- **Loss of private property owners' individual crossing rights.** When HVTL rights-of-way have been purchased by the utility companies in fee simple, most adjacent property owners have been granted crossing rights. In a number of cases, adjacent property owners are allowed to continue to use the land for agricultural purposes. Should a transportation facility be constructed in the corridor, the adjacent property owners' rights would be eliminated. Multiple parcels along a corridor require extensive title searches to determine the property owners affected and negotiation and compensation with these adjacent property owners for this loss. This could slow down any land acquisition process, which would cause this issue to be categorized as an economic issue as well.

Safety Issues:

- **Increased hazards for transportation facility users.** Constructing a transportation facility in an HVTL corridor increases the number of hazards a transportation user would encounter on the facility. The towers are fixed object hazards that drivers could hit. Towers or parts of towers could fall onto the facility, which could cause delays and accidents. If severed or faulted wires come into contact with the facility, users could experience fatal or severe electrical shock.

- **Increased risk to workers during construction and maintenance of the transportation facility.** Using large trucks and construction equipment, such as construction cranes, around HVTLs increases the possibility of a worker being killed or severely injured by electrical shock. A truck or crane could touch, or simply come too close, to the transmission line and cause an electrical shock. Death or severe burns and injuries happen instantly if contact is made with an electrical transmission line. However, the risk for electrical shock is minimal if sufficient clearance is maintained.

- **Impacts on emergency response times.** Depending on power wire converge, a medi-vac helicopter may not be able to land in the corridor. This could increase medical response times as compared to those on other transportation facilities. However, the improved access provided by the transportation facility could provide shorter medical response times over current times to power company employees maintaining the lines.

Environmental Issues:

- **Reduced need to clear forested and wooded areas.** Many HVTL rights-or-way have been substantially cleared of trees to allow clearance for power line sag and sway. This would reduce the need to clear the right-of-way for transportation uses. If a transportation facility is constructed in an HVTL corridor, the incremental negative effects of the transportation facility on water quality, wetlands, air quality, flora and fauna could be similar to or less than in the impacts of a facility constructed in undisturbed woodlands.

- **Negative aesthetic characteristics of the facility.** The sight of the towers, poles and transmission lines could decrease the visual appearance of the transportation facility for some users.

- **Brownfields redevelopment opportunities.** Many HVTL corridors meet the broad definition of a “brownfield” - vacant or underutilized property with real or perceived contamination. If a transportation facility was constructed within a brownfield, it could make better use of the vacant or underutilized property.

- **Environmental Permitting.** Because HVTL corridors are previously disturbed, the number of environmental permits required may be less than for a corridor that is not disturbed. If the number of permits is the same as a disturbed corridor, it may be easier to obtain new permits. However, in order to obtain Federal funds for the project, wetland, tree conservation and sediment and erosion control permits would still be necessary. Although it has not been proved, the potential association between electromagnetic fields (EMF) and certain types of cancer could cause possible permitting issues.

Socio-Economic Issues:

- **Reduced socio-economic and community impacts.** Due to buffer width requirements for HVTL towers and lines, and depending on the design of the transportation facility, homes could be located further from the facility. For example, if a four-lane roadway were located in the center of a 250-foot wide HVTL right-of-way, there would be approximately 100 feet between the edge of pavement and the adjacent property line. This results in a greater distance than typical HVTL scenarios utilized in a majority of highways and arterials.

- **Localizes the effect on people.** Utilizing HVTL rights-of-way should simplify social-economic issues with adjacent property owners and the surrounding public, since the HVTL corridors are generally an accepted land-use within the community. The implementation of a transportation facility would alter this use, but the effects to this change would be less than if the use was previously an environmental conservation area for example.

- **Creates an incremental impact, instead of new impact.**

- **Concentrates linear land uses.**

Cost Issues:

- **Faster, less costly land acquisition process.** If the HVTL corridor right-of-way were owned primarily by the power company, the government would need only deal with one property owner opposed to potentially hundreds. Land acquisition could be resolved in one negotiation and be a minimization of eminent domain issues, speeding the acquirement process. In addition, where adjacent property owners have been granted crossing or agricultural rights, significant negotiations may be needed to eliminate these rights.

- **HVTL and transportation facility geometry.** Depending upon the topography of the HVTL corridor, the cost of building a transportation facility could either increase or decrease accordingly. If the corridor is flat and straight, such as many Maryland HVTL corridors, construction costs may decrease. If the corridor traverses mountainous areas, low-lying wetlands or includes 90-degree turns, construction of the facility could be quite costly. In addition, to ensure safe clearances between power and transportation functions are maintained, it may be necessary to make significant and expensive modifications to the existing power facilities.

- **Limited expansion opportunities.** If a transportation facility is built within the HVTL right-of-way, there will be limited space available to construct additional HVTL towers. Future expansion would require the power companies to purchase additional rights-of-way. This process may be a disadvantage to both power companies and Maryland citizens as the demands upon available electricity increase.

- **Relocation of other utilities.** Within several HVTL corridors, easements have been granted to utility companies for gas and phone lines and fiber optic cables. Construction,

Potential Costs

Developing accurate implementation cost estimates for various transportation options is not possible because they are within hypothetical corridors with unknown variables and a large number of assumptions about the corridors have been made. To prepare a detailed cost estimate, a specific corridor must be selected and an environmental inventory be conducted. This study estimates costs using a 'cost-per-mile' approach. For example, the average ***base*** cost for building a new 4-lane divided freeway ranges between $5 million-per-mile on flat terrain and $6 million-per-mile over mountainous terrain. The base cost excludes "intangibles" such as right-of-way acquisition, structures, utilities, signing, lighting, marking, beautification, preliminary engineering, contingency, and overhead. Because the base cost typically covers earthwork, paving and drainage, base costs would be similar for any highway improvement, regardless of whether it is located within an HVTL corridor. It is the intangibles that create the cost differences. Building a transportation facility in an HVTL corridor will reduce some of the base-cost exclusions, but will increase others.

Cost savings can occur through a simplified right-of-way purchasing process if the power company owns the land and would be willing to allow areas of dedication or to enter into joint usage agreements. Clearing and grubbing costs would be significantly lower, and reforestation mitigation and other environmental costs would be minimized. The light poles and overhead sign lighting associated with interchanges should be easier to construct because of the land has already been cleared. However, even though the transportation facility is located in an electricity corridor, the power for the lights cannot come directly from the HVTL's because the voltages are too high. A separate, lower voltage electrical line would need to be used. Some HVTL corridors already have lower voltage lines within them, and in those cases, costs would be reduced.

The primary additional costs associated with building a transportation facility in an HVTL corridor occur if the terrain is mountainous with multiple steep slopes or there are impacts to avoid with grading. This is because bridges will need to span ravines and retaining walls and barriers will need to be constructed to protect the towers and provide sufficient clearances. The average cost for a bridge is $100 per square foot. Retaining walls cost approximately $50 per square foot. Depressing the transportation facility through the crests to eliminate high grades and to increase safety clearances will increase construction costs and take longer to build as the HVTL structures would need to be protected or moved.

Another cost associated with building a transportation facility in the HVTL right-of-way is relocating existing HVTL towers or poles if they are impacted by the transportation facility. The redesign, relocation or modification of an existing steel lattice towers or large steel pole can cost between $100,000 and $400,000 per structure. In addition, it is not uncommon to find that the relocation or modification of one tower creates the need to relocate or modify the adjacent towers until the transmission lines can be set at a constant tension throughout the tangent section of the corridor. If given the choice between relocating towers or constructing new ones, the power companies would rather construct new, large steel poles adjacent to the existing line because it will be easier to build and will allow for future expansion. Burying the conductor wires is an option, but the cost can be up to 10 times more expensive than relocating the lines above-ground. The increased cost is due to design complexity, cost of materials, electrical arching prevention and construction of casing pipes filled with oil to insulate the wires. Because of the extreme costs and safety requirements associated with insulating 500kv transmissions lines, they cannot be placed underground.

To determine the estimated implementation costs, the study adds the base cost-per-mile for a particular transportation facility to the cost-per-mile increase associated with using the HVTL corridor that occurs and subtracts the cost-per-mile savings associated with using the HVTL corridor. *In general, the cost savings equal the additional costs, leaving little difference between the costs of implementing a transportation facility within an HVTL corridor versus an undisturbed corridor.* However, this finding could vary depending on the specific characteristics of the HVTL corridor. If the corridor's right-of-way is mountainous, is owned by several property owners, and has restrictive tower and/or pole placement, then the cost to construct the transportation facility could be more than 50% greater than building in an undisturbed corridor. Conversely, if the HVTL corridor is owned by one power company, the power lines and structures do not need to be relocated and some environmental mitigation has taken place as part of the HVTL construction, it could cost 50% less to build the transportation facility in the HVTL than in an undisturbed corridor.

Table IV-1 is a cost comparison matrix that breaks down the costs between the various transportation options and corridor configurations.

which would require the relocation or avoidance of these utilities, could impact both maintenance and building costs of the transportation facility.

- **Additional tower protection.** Possibilities exist that vehicles may collide with the stationary power towers, requiring increased protection at the tower base. Examples of such include additional protective fencing and barriers at ground level, or constructing retaining walls.

- **Possible power line relocation.** If a transportation facility built in an HVTL right-of-way requires expansion, the costs associated with the relocation of the power lines would be incurred by the taxpayers.

- **Vertical clearance Constraints.** Design of the transportation facility must take into account the maximum wire sag between towers. Wire sag could limit the allowable vertical clearance of vehicles.

Miscellaneous Issues:

- **Electrical interference.** Electromagnetic Interference (EMI) is the disturbance or electrical noise electromagnetic fields within HVTL's can cause to vehicular radios, cell phones or other electronic devices. The EMI range is dependent on climate and a number of weather variables. For instance, it is such a problem in Hawaii that a "Faraday Shield" was designed and implemented to abate the interference on vehicles traveling along Interstate H-3 , but at high costs.

- **Reciprocity Concerns.** If a transportation facility is built in a HVTL corridor, how will fair compensation be determined? Can the utility companies be compensated for aggravation and loss of time associated with routine HVTL maintenance? Does allowing transportation facilities in existing HVTL corridors create a precedent for allowing HVTL's in existing transportation corridors? These questions illustrate the types of concerns that need to be resolved once the physical and environmental concerns about constructing transportation facilities in HVTL corridors are addressed. Answers will need to be researched thoroughly and possibly with input from lawyers.

V. National and Statewide Examples

V. National and Statewide Examples of Shared Corridor Use

Joint Transportation and HVTL Use Corridors

This section documents examples of power lines and transportation facilities sharing the same corridor. The examples highlight the circumstances that made joint use possible and may not represent typical HVTL and transportation design standards. However, the examples provide opportunities to learn about the types of projects and level of integration possible and to find out the case-specific circumstances that made joint use feasible. The examples cover two types of joint-use corridors. The most common type of joint use corridor is one in which the HVTL use comes in to the corridor after the transportation facility exists. Because of strict guidelines regarding placement of HVTL structures, the safety and operation of the transportation facility is not diminished by the combined use. The second type of joint use corridor – and the one that is the primary concern of this study – is a corridor in which the power company uses the right-of-way and the transportation facility is built after the HVTL line is in place. There are a limited number of examples of this type of joint use corridor, especially over long distances. A final type of corridor would be the design and construction of the HVTL and highway uses together from the outset. However, there are no examples of this type of activity in the United States.

HVTL Corridors Adapted for Transportation Use

The following examples show HVTL corridors adapted to allow for transportation uses in the corridor. The examples illustrate how different transportation modes can be accommodated in close proximity to HVTL structures. Because the examples have unique topography, political will and engineering, the findings they present may not be applicable to conditions in Maryland.

JEFFERSON PARISH, LOUISIANA

In Jefferson Parish, Louisiana, several roads have been constructed almost entirely within existing Louisiana Power and Electric Company's (LaPALCO) HVTL rights-of-way.

- Lapalco Blvd. 8 miles, 4-lane open section, partial control of access.
- Power Blvd. 4 to 6-lane open and closed sections, partial control of access
- Gretna Blvd. 2 to 4-lane residential street, no controls of access
- Stumph Blvd. 4-lane closed section, no controls of access (industrial land use)
- Dickory Avenue 4-lane open and closed section, no controls of access

The highways were designed and built in a way that allows the existing single tower configuration to remain in place as part of the highway median. LaPALCO supported the highway projects because the towers did not have paved access roads for HVTL maintenance and the LaPALCO vehicles were frequently getting stuck in the low-lying, wet terrain.

Photo 18

Trains pass directly beneath and through lattice HVTL towers. I-76 is visible to the right. Both modes share corridor space for approximately ¼ mile.

Photo 19

Even though this lattice structure has a wider base than the one from the above photograph, both, permit two tracks to pass beneath. They also have sufficient vertical clearance (minimum of 22 - feet) to allow double stack container trains.

MD 3 in Crofton

These highways have proved to function safely beside the HVTL's and some of the roads are programmed for widening improvements.

- Power Blvd. (Vet.-W.Espl.) Widen from 4 to 6 lanes
- Lapalco Blvd. (Barataria-Destrehan) Widen from 4 to 6 lanes
- Lapalco Blvd. (Westwood-Barataria) Widen from 4 to 6 lanes

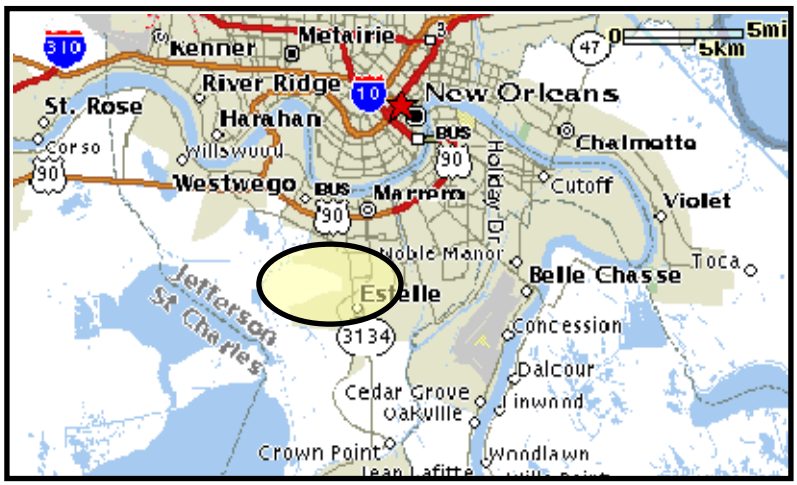


Figure V-1 - Jefferson Parish HVTL Corridor Location.

Photo 9 - Lapalco Blvd. westbound

The outside shoulder of Lapalco Blvd., with oncoming traffic. The towers are in the median. Notice the utility piping bridging over a stream crossing.

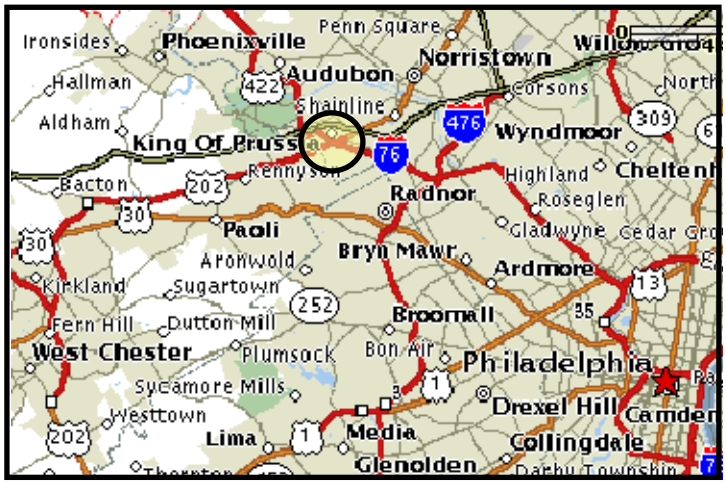
Photo 10 - Lapalco Blvd. eastbound

Lapalco Blvd., looking along the outside edge of pavement.

KING OF PRUSSIA, PENNSYLVANIA

An HVTL corridor near King of Prussia, PA (Figure V-2) provides an example of a using a short segment of an existing HVTL corridor to build a new highway interchange. The surrounding region was completely developed, and the ¾-mile segment needed to connect three major highways was only available along an HVTL right-of-way. This new construction highlights the use (see Photos 11 and 12) of an HVTL corridor to enhance highway connectivity. The exiting steel lattice towers were replaced with steel poles in the joint-use section to provide more flexibility in highway and ramp design.

Figure V-2 - King of Prussia Corridor
I-76, US 202, US 422 Interchange



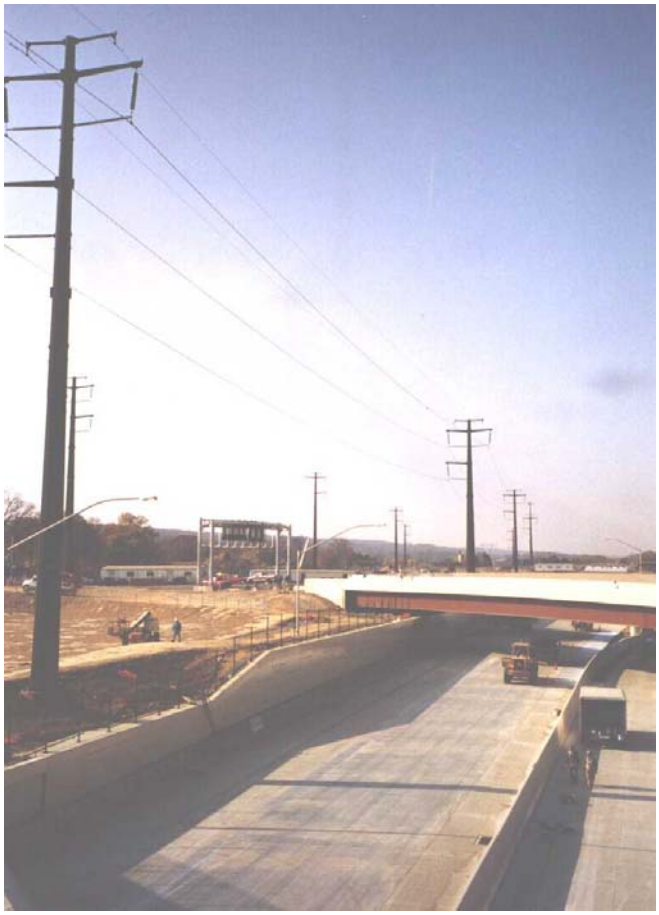


Photo 11

This photo shows that a cut slope and retaining wall is utilized to maintain sufficient vertical clearance between the overpass and the power lines.

Photo 12

Here, *a service road intersection lies directly adjacent to a steel pole. The service road runs at times through the middle of the corridor and between the two lines and also along the outside of the pole bases. The corridor width is generous, at approximately 400' across.*

BALTIMORE LIGHT-RAIL TRANSIT SYSTEM

The Baltimore Light Rail Transit system provides an excellent example of implementing rail transit in close proximity to HVTL structures. In the mid-to-late 1980's, the Maryland Transit Administration (MTA) constructed a light rail line between Westport and Baltimore Highlands that utilized the existing HVTL corridor. Part of the corridor was originally owned by CSX for rail freight purposes, but portions of it were bought by BGE for HVTL's. The light rail tracks run between double circuit steel poles for a short segment near the Westport Stop (see Photos 13 through 17) and run parallel to the poles for a longer segment near Baltimore Highlands Stop.

Initially, BGE was opposed to building the rail line because it was concerned about potential conflicts with HVTL maintenance activities. However, funding and strong political support allowed the transit system to be built. Access to and maintenance of the HVTL structures has been arranged at the least possible inconvenience of either MTA or BGE in the extremely tight quarters illustrated in the following photos. Using the HVTL corridor allowed the light rail line to be built without disrupting adjacent properties while preserving a critical HVTL corridor into the city.

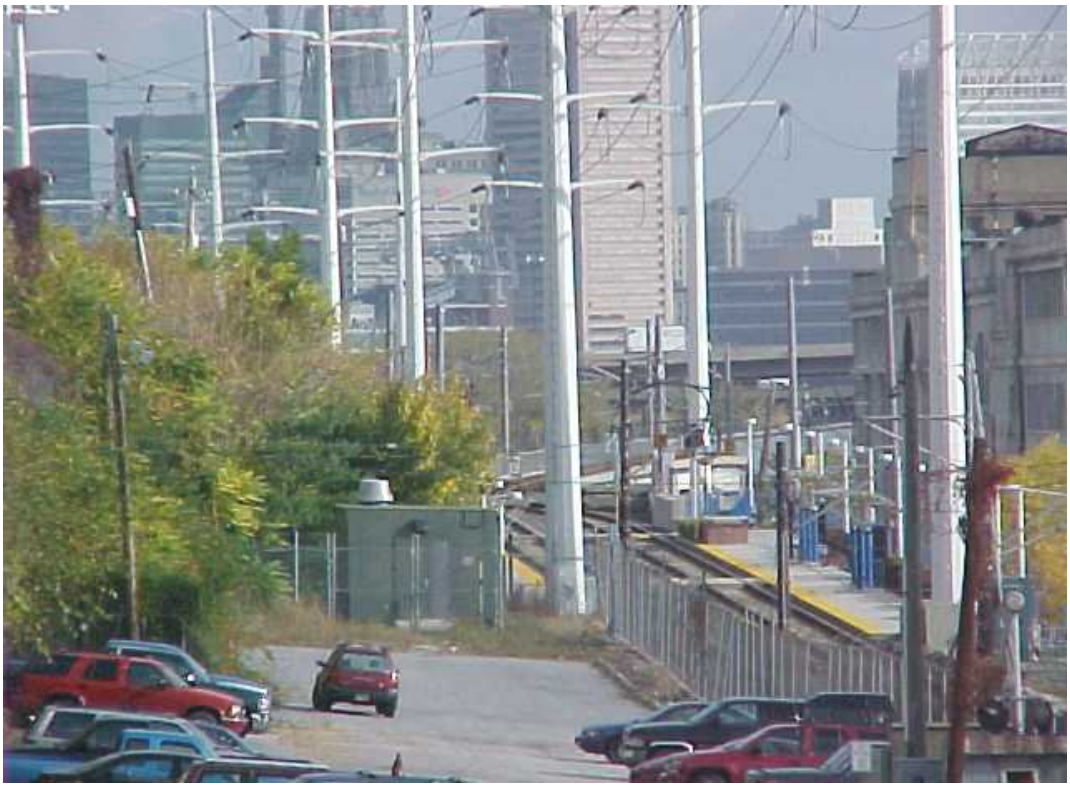


Photo 13

Looking north toward the Westport Station. The train lines are located between the two sets of HVTL towers.

Photo 14

The towers afford little horizontal clearance for passing trains in this view from Westport station.

Photo 15

A steel and concrete barrier provides the steel pole with protection from northbound trains (see Figure V-3).

Photo 16

Another view of the steel pole shown in Figure 1. It has a 52-inch diameter with an 8 ft diameter concrete base.

Photo 17
Looking across tracks at the steel pole and concrete barrier adjacent to the southbound track.

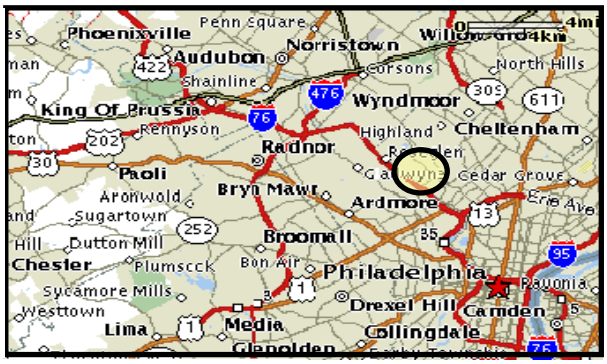
Transportation Corridors Adapted for HVTL Use

There are many more examples of transportation corridors being used for HVTL use, than HVTL corridors being used for transportation purposes. Transportation corridors have higher design standards than HVTL design standards. This is because of vehicle performance limitations and safety considerations. A result of the higher design standards is that it is easier to develop an HVTL in a transportation corridor than the other way around.

Philadelphia, PENNSYLVANIA

Topography limited the space available for an HVTL corridor along the Schuylkill River approaching Center City (see Figure V-4). Along this particularly narrow point, both the local power company and the Pennsylvania Department of Transportation were able to utilize the same segment of this corridor in very close proximity. The topography and constraints of the corridor required specially engineered structures to be used. (See Photos 18 and 19). The corridor had been initially purchased to construct a rail freight line in the late 1800's.

Figure V-4 - Norfolk Southern Main Line



Whereas the Baltimore LRT located within segments of a previously existing HVTL corridor, it is far more common for utility companies to locate within existing transportation corridors. An example from Maryland is along MD 3 near Crofton. The Maryland Department of Transportation State Highway Administration (SHA) has specific policy that governs the placement of such utility structures within highway rights-of-way. The SHA Utility Policy indicates the necessary clear zone required for safety reasons beside highways. These standards are represented by the horizontal separation between road and steel poles, while in this example the transmission line is located just outside the highway right-of-way on private land. The need for increased safety buffers along highways contrasts with the Baltimore Westport LRT example, where tight spacing was allowable between poles and light rail vehicles. The horizontal clearances are shown in detail in Figure V-5.

Photo 20

Looking south along MD 3 southbound lanes. The 2.5-foot diameter steel poles carry transmission lines of 115,000 volts.

The previous examples are either functional facilities or are very near completion. Locally, there are several projects in the planning stages that could potentially have joint-use HVTL implications. These projects would provide the most immediate application of the recommendations of this HVTL study. Descriptions of some example projects within Maryland and West Virginia are provided below.

- ***The Baltimore-Washington Maglev Project***

  This Federally funded study is evaluating several high-speed rail alignments to connect Baltimore and Washington. One alignment utilizes for several miles an HVTL right-of-way that has a dual configuration of steel and lattice towers. All alternatives are still under evaluation and no date has been set for an alternate to be chosen.

- ***College Park Connection from I-95 (2012 Olympics)***

  SHA's Regional Planning Office is conducting this study. One of the options is utilizing the HVTL right-of-way that extends south from the I-95/I-495 interchange towards College Park and beyond.

- ***Northeast Baltimore Corridor Study***

  This feasibility study was conducted by MTA to explore opportunities to extend rail transit from downtown Baltimore to the White Marsh area. Several alternatives looked at using the HVTL corridor that connects northeastern Baltimore City and the White Marsh Area. This project has recently been funded for further study

- ***West Virginia Route 9***

  West Virginia Division of Highways initiated this study based on a future highway alignment shown in the adopted local Master Plan. As part of the NEPA evaluation process, other alignments were evaluated. While the study was being conducted, Allegheny Power built HVTL's within the master plan alignment. Joint usage is still a possibility since no highway alignment has been selected.

Transportation Facilities with HVTL Crossings

Maryland has many examples of transportation facilities and HVTL structures crossing.

The study team took some trips to the field to investigate HVTL crossings of existing transportation facilities in order to witness the clearance distances between the HVTL towers, transmission lines and highway / rail track. The purpose was to determine if there were any issues associated with these crossings that may help to develop an understanding of joint-usage possibilities.

One observation was discovering how many HVTL crossings there are within Maryland, and realizing how close some of the tower structures are to the edge of highway / rail track. The following paragraphs and photos represent key examples of these crossings and how they hinder future expansion possibilities for the transportation facility.

MD 32 – ANNE ARUNDEL COUNTY

This 115,000-volt transmission line corridor crosses MD 32 several times and runs parallel to the roadway for several miles (see Photo 21 through 23). One key observation was the close proximity of one of the towers situated in the median of MD 32, near the National Security Agency. The HVTL corridor crosses at a skewed angle in this instance.

Photo 21

The photographer is looking west along the median barrier of westbound MD 32. The HVTL tower is a lattice tower with a square base of 30 feet on each side. There is 19-foot horizontal clearance between the concrete base of the tower and the face of steel barrier.

Photo 22

This photo shows another view of the lattice tower shown in Photo 21. This view is from the outside of MD 32 westbound, looking towards the eastbound lanes. (See Figure V-6 for a plan view sketch.)

Photo 23

The HVTL Corridor is parallel to MD 32, south of the freeway. Note that the closest two lattice towers have extended heights to accommodate a long span and still maintain minimum vertical clearance distances between the transmission wire midpoint sag and the ground elevations.

MD 170 – ODENTON

This HVTL corridor crosses MD 170 at a skewed angle, near the town of Odenton. Note how the transmission wires span from a lattice tower to a steel pole in the distance; refer to Photo 24 below. The observation here is how close the towers are to the curbs, with no barriers. This was accepted most likely due to the lower design speed of 35mph along MD 170, which caused less of fixed object hazard risk. The sidewalk is even closer to the towers.

Photo 24

Looking north along the MD 170 southbound lanes. The steel (lattice) tower is 15 feet from the travel lane. (See Figure V-7 for a plan view sketch.)

Photo 25

Looking north along the sidewalk adjacent to the northbound lanes of MD 170. The diameter of the steel pole is slightly more than 4 feet. The distance between the base of the pole and the travel lane is 9.5 feet. (See Figure V-8 for a plan view sketch.)

Photo 26

A closer look at the wide steel pole adjacent to northbound MD 170.

I-95 / I-495 INTERCHANGE – COLLEGE PARK

This is feasible and practical since the towers / poles can be places within the acres of underutilized land areas between the ramps and travel lanes of these major interchange configurations (see Photo 27).

Photo 27 - *Large HVTL structures within the I-95/I-495 interchange*

Photo provided by Bryne Kelly

There are several completed or ongoing transportation studies in Maryland with HVTL corridor right-of-way impacts, primarily due to perpendicular crossings HVTL crossings under study in the region include:

- ***MD 43 – Middle River Extension (Baltimore County)***

  This project led by SHA is in Final Design. To accommodate maximum sag conditions, the transmission line height need to be at least 30-feet over the proposed highway. BGE is working with SHA to adjust tower and transmission line heights. Preliminary cost estimates for tower and transmission line modifications and relocations are approximately $600,000.

- ***MD 33 – St. Michael's Bypass (Talbot County)***

  This project led by SHA almost made it through Final Design before the project was canceled due to an inability to obtain environmental permits. Some HVTL rights-of-way were purchased from, but will now be sold back.

- ***US 301 – Waldorf Upgrade / Bypass Study (Charles County)***

  The eastern bypass alternative for Waldorf crosses an existing HVTL corridor several times and runs either within or alongside the corridor for several hundred yards. This alternative is still being evaluated and a Public Hearing on the alternatives is scheduled for 2002.

Appendix B

Typical Sections Pursued but Dropped

Appendix B

The following typical sections (Figures B-1 through B-14) were considered but dropped because of design and implementation difficulties and potential safety hazards for users of the transportation facility. Minimum horizontal clearances not being met and not having enough available land between HVTL structures to even place the transportation facility, excluding the additional buffer areas required for safety, were the overriding issues. Otherwise, only a two-lane highway or a single-track rail line could fit. For the case of the full build-out (three steel poles, with diameters representing the maximum concrete base or footer), a two-lane highway "inside configuration" had to be used, satisfying a 15 foot clearance requirement on both sides. For rail transit, an inside and outside configuration was considered, but that hinders HVTL maintenance activities. Any "split rail option" (outside configuration) will complicate transit system operations, primarily at stations. Any inside configuration for a full build-out scenario would serve as the 'worst-case' option from a transportation facility user's viewpoint, as well as for HVTL maintenance operations. For a dual steel pole structure scenario, some specific designs can be accommodated. For example, a four-lane highway "inside configuration" could fit between the HVTL structures, but it would limit any possibility for future expansion to the highway or to the HVTL, unless the entire HVTL structures are relocated.

Safety and aesthetics are also important. An additional concrete median barrier used to separate opposing traffic flows could present a safety issue if the required shoulders were unable to fit within the right-of-way. The dual steel lattice tower scenario represents the configuration with the least amount of available land between the towers for transportation facility implementation. Any transportation system had to be located on the "outside" of the these towers.

TABLE VI-2 Transportation Options Comparison Matrix

Corridor / Structure Configuration	HIGHWAY			RAIL			
	2-Lane Highway	4 Lanes Highways /Expressways	4 Lanes Expressway with Rail Option	Light Rail / Busway	Heavy Rail (AMTRAK / MARC)	SkyTrain	Maglev
250' Corridor Dual Steel (Lattice) Towers	Good Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly	Does Not Meet Clearance Req. w/out Barriers Structure within median HVTL Maint. Access Issues Construction More Costly	Does Not Meet Clearance Req. w/out Barriers Structure(s) within median(s) Major HVTL Maint. Access Issues Construction More Costly	Good Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues Construction More Costly	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues No difference in Construction Costs, unless there are vertical clearance issues	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues Construction more costly, especially when HVTL structures are located on crests
250' Corridor One Steel (Lattice) Tower, One Steel Pole	Good Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly	Does Not Meet Clearance Req. w/out Barriers Structure within median HVTL Maint. Access Issues No difference in Construction Costs	Does Not Meet Clearance Req. w/out Barriers Structure(s) within median(s) HVTL Maint. Access Issues No difference in Construction Costs	Good Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues Construction More Costly	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues No difference in Construction Costs, unless there are vertical clearance issues	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues Construction more costly, especially when HVTL structures are located on crests
250' Corridor Dual Steel Poles	Best Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly Best Vertical Clearance	Does Not Meet Clearance Req. w/out Barriers Structure within median Minor HVTL Maint. Access Issues No difference in Construction Costs	Does Not Meet Clearance Req. w/out Barriers Structure(s) within median(s) HVTL Maint. Access Issues No difference in Construction Costs	Good Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues Construction More Costly	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues No difference in Construction Costs, unless there are vertical clearance issues	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues Construction more costly, especially when HVTL structures are located on crests
250' Corridor Triple Steel Poles (Full Buildout)	Good Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly	Does Not Meet Clearance Req. w/out Barriers Structure(s) within median HVTL Maint. Access Issues Construction More Costly	Does Not Meet Clearance Req. w/out Barriers Structure(s) within median(s) Major HVTL Maint. Access Issues Construction More Costly	Good Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues Construction More Costly	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues No difference in Construction Costs, unless there are vertical clearance issues	Does Not Meet Clearance Req. w/out Barriers Minor HVTL Maint. Access Issues Construction more costly, especially when HVTL structures are located on crests
150' Corridor (Full Buildout)	Good Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly	Considered, but Dropped *due to lack of available space between structures*	Considered, but Dropped *due to lack of available space between structures*	Good Horizontal Clearance Existing low-voltage Wooden Poles to be Relocated or Altered HVTL Maint. Access Issues Construction More Costly	Does Not Meet Clearance Req. w/out Barriers Existing low-voltage Wooden Poles to be Relocated or Altered HVTL Maint. Access Issues Construction More Costly	Does Not Meet Clearance Req. w/out Barriers Existing low-voltage Wooden Poles to be Relocated or Altered HVTL Maint. Access Issues Construction More Costly	Does Not Meet Clearance Req. w/out Barriers Existing low-voltage Wooden Poles to be Relocated or Altered Construction more costly, especially when HVTL structures are located on crests

NOTES:

Color coding - - **Blue is positive,** Green is Neutral, **Orange is sligtly negative,** and **Red is negative**

Costs are based on the positive or negative percentage values shown in Figure IV-1

APPENDIX G: 1993 PENINSULA ROUTE ASSESSMENT BY D. W. DODSON

J. O. Austin's Copy

Preliminary Engineering Feasibility Study

of an

Additional High Speed Track

between

Richmond, Virginia and Newport News, Virginia

August 1993

for

Commonwealth of Virginia

Department of Rail and Public Transportation

by
D. W. Dodson
Consulting Engineer

Acknowledgement and Disclaimer

This report was prepared in cooperation with the Virginia Department of Rail and Public Transportation and the Virginia Department of Transportation.

The contents of this report reflect the views of the consultant who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Virginia Department of Transportation or the Virginia Department of Rail and Public Transportation. This report does not constitute a standard, specification, or regulation.

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Purpose and Scope

The Department of Rail and Public Transportation and the Virginia Department of Transportation have undertaken a preliminary feasibility study of constructing an additional track for high speed rail passenger service between Richmond, Virginia, and Newport News, Virginia. The proposed track will use the same general alignment as the existing CSX trackage. The Commonwealth has retained D. W. Dodson to make this preliminary study.

The study will be conducted in two parts. The first part will assume the additional track will follow the existing CSX alignment with an operating speed of 150 mph, except where limited by track restrictions. The second part of the study will assume an operating speed of 150 mph is to be attained wherever practical, with necessary alignment changes. Both parts will include speed restrictions in congested areas such as the cities of Richmond, Williamsburg, Newport News, and adjacent suburbs.

This report contains the results of this feasibility study. Contained herein are the following items, supporting each of the two parts:

1. An assessment of the existing conditions between Newport News and Richmond

2. A series of sketches indicating tentative track locations for a proposed additional track between Newport News and Richmond

3. An analysis of the problem areas including highways and railroad bridges

4. Preliminary cost estimate with electrification costs if deemed desirable

5. Where additional track is on CSX right-of-way, a minimum of 20 feet between existing main line track and a proposed high speed track is recommended.

Assessment of Existing Conditions

CSX Corporation owns and operates the rail corridor between Fulton Yard (M.P. 82) in Richmond and Old Point Junction (M.P. 11.5±) in Newport News. The width of the right-of-way is normally 100 feet. The entire right-of-way was designed for double main line operation but, with the use of automatic block signal systems, much of the former eastbound main track has been retired; where the former eastbound track is still in place, it is used as a passing track or lead track for industry sidings. Due to the abandonment of the track, most unused right-of-way is on the south side and is now used for a company access road. Also, most bridges and drainage structures, which formerly supported the eastbound main, were abandoned in place and a structural study would have to be made to determine the integrity of each structure and its ability to handle high speed passenger trains, if desired.

Curvature of the track is not overly severe; the worst curve is a 3°00′ curve right with a delta of 37°34′ and length of 2540 feet, followed immediately by a 3°00′ curve left with a delta of 36°00; and a length of 1400 feet. These two curves are immediately adjacent to the north bank of the Chickahominy River in New Kent County. The river bluffs in this vicinity constitute some of the worst terrain within the area of study. Additionally, there are three curves between 0°30′ and 0°59′; 13 curves between 1°00′ and 1°59′; and 7 curves between 2°00′ and 2°30′, for a total of 23 curves over 0°30′.

Existing right-of-way contains ample track drainage facilities, from 12" pipes to 4′ brick and/or concrete arches. Major facilities include 15 highway overpasses, 8 highway underpasses, 16 railway bridges over water, and 6 major arch structures for streams.

There are 32 private grade crossings and 25 public grade crossings, for a total of 57 at-grade crossings over the main line. Of the public grade crossings, 12 have train activated automatic flashing light gate signals, 6 have train activated automatic flashing light signals, and 7 have passive warning devices. The private crossing in the Williamsburg Pottery Factory in Lightfoot has warning devices which consist of train

activated flashing light gate signals. The crossing is located adjacent to a pedestrian underpass.

Overall, the south side of the right-of-way allows the greater flexibility in constructing an additional track on or near CSX property. However, there are several problems which will have to be further analyzed and solved. Approximately four miles of private roadway currently are being used and, in all probability, the user(s) either have a deed reservation or prescriptive right to the roadway. Further, approximately 2.5 miles of public roads are located on CSX property. The right-of-way for US Rt. 60 is adjacent to CSX right-of-way on the south side for approximately 35 miles and on the north side for approximately seven miles. In some areas of CSX right-of-way, between Williamsburg and Newport News, Interstate 64 and US 143 are located close to the railway and will further complicate any track relocation or construction.

From the yard limit sign at the west end of the Newport News Classification Yards to the yard limit sign at the east end of the Fulton Yards, there are 17 switches coming off the south side of the main line(s) and 20 switches coming off the north side. It is possible that some of these can be removed, but many cannot. However, the most active sidings are in or near the urban centers and will be in slow speed areas.

Due to CSX Corporation's acquisition of the trackage of the former Richmond, Fredericksburg & Potomac Railroad Company in 1991, in particular the RF&P's yards north of Richmond, CSX's Fulton Yard in the City of Richmond is being studied to determine if the yard can be significantly reduced. For the purpose of this report, it will be assumed that the yard will stay in place and the study will be terminated on the east end of the yard.

As previously alluded to, there are three areas of congestion: Richmond, Williamsburg, and Newport News. The area on the east side of Fulton Yards is fairly open and should not require any significant relocation of homes or industries. The only potential problem noted

would be the possible disruption of some facilities of Virginia Air National Guard and Richmond's Richard Evelyn Byrd International Airport. It is believed that part of a roadway used by the National Guard is on the south side of CSX property. Many airports have "clear zone easements" adjacent to their approach runways. This will have to be considered if electrification towers and/or microwave towers were to be erected in the vicinity of the airport.

The entry into Newport News could be more difficult. Whereas CSX has ample right-of-way for an additional track, it is not known if they have any future development plans for the property. Both sides of CSX are virtually full of adjacent and cross streets, private living quarters, and industries, both large and small. Therefore, it is essential to stay on or as close to CSX property as feasible.

The urban and suburban areas around the City of Williamsburg, including the Town of Lightfoot, the Williamsburg Pottery Factory, and historic Colonial Williamsburg, will present the more challenging problem. The area through the pottery factory complex is fully developed and an additional high speed track would disrupt the business and parking facilities. Also, it would be very expensive to compensate for this disruption. The existing trackage through the City of Williamsburg lies in a depressed area with embankments in excess of 15' above the top of rail. Any attempt to use existing CSX right-of-way would disrupt adjacent streets, parking lots, and stores on the south side, including some facilities of Colonial Williamsburg, such as the Colonial Parkway.

The recommendation is to review the possibility of bypassing Williamsburg and the above-named facilities. From county and geological maps and a cursory review of the terrain, it appears feasible to leave CSX right-of-way at approximately railway milepost 45.5, approaching Interstate 64 approximately one mile east of the Norge Interchange and continue paralleling the interstate into the northwest corner of Newport News where I-64, US Rt. 60, SR 143, and the railway converge. From that point to the end, CSX property may be utilized.

The advantage of the CSX route appears to be very conducive to a high speed rail operation. Generally, there are no large, populated areas, with the exception of those noted above, resulting in little disruption to individuals and/or businesses. Much public and/or railroad right-of-way can be utilized for such an endeavor, including portions of CSX, US Rt. 60, SR 143, and Interstate 64. As noted above, the only intermediate populated area would be Williamsburg and adjacent suburban areas.

The final consideration to discuss would be the terrain. A general review of the geodetic maps of area and a cursory review of the entire area, there is only one notable area where the terrain becomes erratic, both with rough landscape and adjacent or nearby water. This occurs generally on the Walkers geodetic map south of US Rt. 60, west of Rt. 627, north of the Wilcox Neck of the Chickahominy River, and ending east of Rt. 601 and the Hicks Island area. This general area coincides with portions of CSX valuation maps Y-2/34 and V-2/35. From the CSX maps, the two worst curves, each in excess of 3°00′, are in this area and, by realignment, these two curves could be eliminated. Even by staying on CSX property, terrain features would make it difficult and expensive to construct a high speed track within this approximately three mile strip. Therefore, it is recommended that entirely new alignment from a point east of Walkers to point near the New Kent-James City County line be considered. This would be approximately 2.5 miles.

As noted above, the writer feels the south side of CSX right-of-way offers the most advantageous location of the high speed track and all discussions will be based on this premise.

Existing Alignment Scenario
Analysis of Problem Areas

M.P. 11.5± - 14.36 - Classification Yards for Old Point Junction in Newport News:
CSX will have to determine if room is available for separate track. From the right-of-way and track map, there is a small area on the south side, east of Mercury Blvd., where there is insufficient room for a third main line.

M.P. 14.24 - Center Av. underpass:
There are four tracks over bridge with approximately 40 feet on south side. Part of the bridge has been retired in place and room is available for an additional track.

M.P. 14.97 - Main St. (Rt. 152) underpass:
There are two tracks over bridge with a portion of bridge retired in place. However, width is insufficient for third main line and will have to be widened or replaced.

M.P. 15.37 - Switch on south side to various facilities:
Business interests will decree whether track can be eliminated.

M.P. 16.53 - End of passing track:
Single track for next 5.9 miles.

M.P. 16.55 - Harpersville Rd. grade crossing:
Traffic control devices consist of automatic flashing light signals with

short arm gates. Double-track grade separation required.

M.P. 17.55 - 10′ brick and concrete arch structure for Causey's Mill Pond:
Structure will have to be lengthened or rebuilt for high speed tracks.

M.P. 17.58 - 8′ x 8′ concrete box underpass:
Will have to be lengthened or rebuilt for high speed tracks.

M.P. 17.74 - J. Clyde Morris Blvd. overpass:
A survey will be necessary to determine adequacy of clearance for an additional track.

M.P. 17.67 - 19.52 - A private road is on south side of right-of-way and would have to be relocated.

M.P. 19.55 - Private grade crossing:
Should be closed and alternate access provided at Bell King Road, M.P. 19.77, including a parallel drive on north side of right-of-way.

M.P. 20.01 - 20.50 - Private road on south side of right-of-way will require relocation.

M.P. 20.21 - 20.38 - 0°40′ curve left, 867 feet long:
0°30′ curve can be constructed with minimal effort.

M.P. 20.47 - Oyster Point Rd. overpass:
Adequate room to add a high speed track.

M.P. 20.87 - 12' concrete arch structure for Deep Creek:
Will require lengthening or reconstruction for high speed track.

M.P. 22.0 - Eastwood Bland Connection Rd. overpass:
Should be adequate for an additional high speed track.

M.P. 22.30 - 22.65 - Private road on south side of right-of-way:
Will require relocation.

M.P. 22.41 - 35.24 - Second main line included on south side.

M.P. 22.76 - Point of switch to two industrial sidings, Nos. 487 and 2921, on south side:
Track No. 487 would negate an additional high speed track on south side of right-of-way. Interstate 64 would deter any shifting of track in a northerly direction.

M.P. 22.84 - Rt. 173 overpass:
This structure further complicates the installation of a high speed track, as it spans industrial sidings, Nos. 487 and 2921, as noted at M.P. 22.76.

M.P. 23.3 - Deck Girder Bridge over Stony Creek:
New single-track structure will be required.

M.P. 25.3 - Industrial Park Dr. grade crossing: Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A grade separation structure will be required.

M.P. 25.51 - Point of switch to track No. 490: Track retired in place and can be removed.

M.P. 26.00 - Rt. 105 overpass: Should be adequate for an additional track.

M.P. 26.43 - 12′ arch for Warwick River: Will require widening or reconstruction for a high speed track.

M.P. 26.49 - PS for passing siding No. 493 on south side, length is 5661 feet.

M.P. 26.73 - PS for Ft. Eustis track No. 491 on south side off passing siding No. 493.

M.P. 26.83 - PS for storage track No. 492, length is 3577 feet, on south side off passing siding No. 493.

M.P. 27.38 - PS for track No. 494 off storage track on south side.

M.P. 27.52 - Yorktown Rd. grade crossing: Traffic control devices consist of train activated automatic flashing light signals. Grade separation structure will be required.

M.P. 27.53 - PS for track No. 495 off south side of passing siding No. 493 with track No. 2104 coming off track No. 495.

M.P. 27.62 - Elmhurst Dr. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals and short arm gates. Grade separation structure will be required.

Note: The section of track from M.P. 26.49 to 27.77 will require additional study to determine if any of sidings Nos. 493, 491, 492, 494, 495, and 2104 can be removed. Also, it will have to be determined if the grade crossings of Yorktown Road and Elmhurst Drive can be combined, thereby closing one crossing and eliminating the need for two new grade separation structures.

M.P. 28.06 - Private grade crossing:
Either alternate access or an underpass will be necessary if required to maintain access.

M.P. 28.33 - 29.16 - 0°44′ curve left:
Any attempt to obtain a 0°30′ curve left will require the relocation of approximately 3000 feet of US Rt. 60.

M.P. 29.86 - 30.23 - 0°56′ curve right:
To obtain a 0°30′ curve would require the relocation of portions of SR 168, the two main lines, and Dow Chemical Track No. 2791.

M.P. 30.0 - 30.81 - Private road on right-of-way will have to be relocated.

M.P. 30.60 - PS to Dow Chemical Track No. 2791, on south side of right-of-way

M.P. 31.92 - 32.19 - 2°00′ curve left:
No practical way to improve curvature due to proximity of US Rt. 60 on south side of right-of-way.

M.P. 32.46 - PS to track No. 2990 on south side:
Tracks Nos. 2991, 3013, and 3015 also come off track No. 2990, in a southerly direction. Track No. 2991 serves Busch Gardens facilities. Due to close proximity of SR 168 on north side and US Rt. 60 on the south side, a detailed survey will have to be made for any alternatives.

M.P. 32.81 - 33.09 - 2°00′ curve right:
No practical way to improve curvature at this location, as may be noted under comments for PS at M.P. 32.46.

M.P. 34.11 - Rt. 199 overpass twin highway bridge:
Should be good for additional high speed track.

M.P. 35.24 - 42.87 - Single track

M.P. 36.15 - Page Rd. overpass highway bridge:
Need survey to determine if adequate for additional high speed track.

M.P. 36.02 - 36.77 - 1°00′ curve left:
Possible to decrease curvature for high speed track by shifting CSX track in a northerly direction. However, this could affect clearances at Page Road overpass and the Capitol Landing Road overpass.

M.P. 36.30 - Capitol Landing overhead highway structure:
Should be adequate for an additional high speed track.

M.P. 36.64 - Pedestrian underpass:
Will require lengthening.

M.P. 36.75 - Colonial National Parkway underpass:
Will require lengthening.

M.P. 37.00 - 38.26 - 1°00′ curve right:
In the Williamsburg city limits. No practical way to reduce curvature.

M.P. 37.15 - Henry Street grade crossing:
Traffic control devices consist of train activated automatic flashing light signals and short arm gates. Crossing will have to be closed or bridged.

M.P. 37.30 - Covered platform and station facilities for City of Williamsburg on south side.

M.P. 37.76 - PS for track No. 504 on south side:
Shows little apparent use and possibly could be removed.

M.P. 38.25 - Rt. 60 overhead highway bridge:
Should be adequate for an additional high speed track.

M.P. 38.60 - Private grade crossing:
Arrangements will have to be made to provide access.

M.P. 38.95 - Private grade crossing:
Arrangements will have to be made to provide access. One underpass may suffice for the two crossings or an alternate access may be provided by extending Rt. 603.

M.P. 40.17 - Rt. 645 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. Will need underpass to span CSX and high speed track.

M.P. 40.84 - 41.17 - 1°00′ curve left:
Impractical to reduce curvature due to close proximity of US Rt. 60 on the south side.

M.P. 42.40 - Rt. 646 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals. If not feasible to closed, a double-track grade separation will be required.

M.P. 42.87 - 49.22 - Double track

M.P. 42.93 - 43.24 - 1°00′ compound curve right

M.P. 43.11 - PS for passing track No. 515 on south side:
Length of track is 7518 feet.

M.P. 43.15 - Private grade crossing for Williamsburg Pottery complex:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. Immediately adjacent to east side of at-grade crossing is a pedestrian underpass. Will be very difficult to make any changes in this complex.

M.P. 43.40 - Private farm crossing:
Four track grade separation required if access is deemed necessary.

M.P. 43.70 - Private farm crossing:
Four track grade separation required if access is deemed necessary. No apparent connection to farm crossing at M.P. 43.40.

M.P. 43.95 - Private grade crossing for one house:
No other apparent access.

M.P. 44.25 - Private farm crossing:
Four-track grade separation required if access is deemed necessary. No other apparent access.

M.P. 44.60 - Private grade crossing for three houses:
No other apparent access.

M.P. 44.74 - 45.83 - 1°18′ compound curve left:
Difficult to decrease curvature due to county road on south side.

M.P. 45.70 - SR 602 overhead highway bridge:
Adequacy of the clearance depends on layout of track structure.

M.P. 45.86 - PS for track No. 3066 on south side:
Review for retirement.

M.P. 46.32 - 46.63 - 2°00′ curve right:
A detailed survey of the terrain on the north side required to determine if a curvature reduction would be satisfactory. No other problems noted.

M.P. 45.56 - PS to track No. 520 on south side:
Possible to retire all tracks.

M.P. 46.84 - 47.14 - 2°00′ curve right:
No apparent problems to shift all tracks in a northerly direction for decreased curvature.

M.P. 47.07 - US Rt. 60 overpass:
Appears adequate for an additional high speed track.

M.P. 47.36 - 47.60 - 2°00′ curve left:
No apparent reason on south side not to decrease curvature for a high speed line.

M.P. 47.79 - 48.26 - 1°52′ curve left:
No apparent reason on south side not to decrease curvature for a high speed line.

M.P. 49.24 - 49.80 - 3°00′ compound curve right:
North side has potential for decreasing curvature. Detailed land survey will be required to determine feasibility.

M.P. 50.19 - 50.65 - 1°55′ curve left:
South side has potential for decreasing curvature. Detailed land survey will be required to determine feasibility.

M.P. 50.77 - 12′ brick arch:
Will need lengthening or reconstruction.

M.P. 50.82 - 51.25 - 1°10′ curve right:
Does not appear to be feasible for further shift in southerly direction due to terrain and houses.

M.P. 51.02 - Forge Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. Double-track grade separation structure will be required.

M.P. 51.0 - 52.0 - Publicly used road on right-of-way:
Right of individuals to use roadway will have to be established and legally dealt with.

M.P. 52.35 - Rt. 601 underpass:
Will have to be lengthened or reconstructed for high speed track.

M.P. 52.51 - Diascund Creek bridge:
Single-track bridge will be required for high speed track.

M.P. 52.69 - 52.97 - 2°30′ curve left:
Terrain does not appear feasible to shift track in a southerly direction. Total realignment may be necessary in this area. Recommend eliminating curve by extending

track relocation as outlined for curves at M.P. 53.18 - 53.05 and at M.P. 53.51 - 54.00 noted below.

M.P. 52.97 - SR 1010 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A double-track grade separation structure will be required.

M.P. 53.18 - 53.45 - 3°04′ curve left:
Terrain not conducive for a track shift in a southerly direction. Recommend total realignment. See recommendation for curve at M.P. 53.51 - 54.00 below.

M.P. 53.49 - 53.70 - SR 627 on right-of-way:
A road shift will be difficult and expensive due to nearby private homes.

M.P. 53.51 - 54.00 - 3°00′ compound curve right:
Total realignment will be necessary to decrease track curvature. Recommend relocating tracks approximately 1500′ north, beginning at about M.P. 55.25 and designing a 0°30 curve right, ending at approximately M.P. 53.50.

M.P. 53.67 - 6′ brick arch, 72′ long:
Probably adequate for an additional track.

M.P. 53.90 - Private grade crossing to several residences:
Access could be provided from SR 627.

M.P. 54.23 - Rt. 627 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A double-track grade separation structure will be required.

M.P. 55.22 - Public grade crossing, SR 647 to Chickahominy Lake outpost, easement to USA:
Will have to be provided for unless crossing can be consolidated with private crossings at M.P. 55.37 and 55.49.

M.P. 55.37 - Private grade crossing to four homes:
Investigate alternate access.

M.P. 55.49 - Private grade crossing to Chickahominy Lake:
Investigate alternate access.

M.P. 56.04 - 56.45 - 1°00′ curve left:
Any potential CSX shift would be minimal due to location of US Rt. 60 on the north side. A 0°30′ curve can be constructed on south side of right-of-way without disturbing CSX track.

M.P. 56.57 - Private grade crossing:
There does not appear to be an alternate access. An underpass will be required, if access deemed necessary, due to close proximity of US Rt. 60 on north side.

M.P. 56.93 - Private grade crossing:
There does not appear to be an alternate

access unless a parallel access road is constructed.

M.P. 57.08 - Brick arch and 96" liner plate:
Both drainage structures will have to be lengthened.

M.P. 57.15 - Public grade crossing, SR 647, leading to Osborn Landing:
Access will have to be maintained.

M.P. 57.35 - Private grade crossing leading to several houses:
Access will have to be maintained.

M.P. 57.70 - Rt. 650 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. Access will have to be maintained with a grade separation structure.

M.P. 57.95 - Private grade crossing:
No alternate access available.

M.P. 57.86 - 58.14 - 0°30' curve right:
No problem.

M.P. 58.55 - Private grade crossing to state game farm:
Access will have to be maintained.

M.P. 58.65 - 61.13 - Double track

M.P. 58.72 - Private grade crossing:
No alternate access available.

Note: The private and public grade crossings at M.P. 56.57, 56.93, 57.15, 57.35, 57.70, 57.95, 58.55, and 58.72 could be consolidated with one underpass if a parallel access road could be constructed. The structure would have to be an underpass due to the close proximity of US Rt. 60.

M.P. 59.27 - 59.42 - 0°30′ curve left:
No problem.

M.P. 59.93 - PS to track No. 534 (passing track) on south side, length is 5805 feet:
(To stay on right-of-way, track No. 534 will have to be eliminated.)

M.P. 60.12 - Private farm crossing:
Alternate access may be available.

M.P. 60.53 - 60.74 - 0°30′ curve left:
No problem.

M.P. 60.80 - Rt. 602 grade crossing:
Traffic control devices consist of passive warning signs. A double-track grade separation structure will be required.

M.P. 60.98 - PS for track No. 536 on south side:
Two additional industry tracks, Nos. 2869 and 2939, lead from track No. 536.

M.P. 61.13 - 76.20 - Single track

M.P. 61.27 - SR 155 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals

with short arm gates. A grade separation structure will be required. The structure could be used to close the Rt. 602 grade crossing at M.P. 60.80.

M.P. 61.54 - Deck plate girder bridge over Jones Run (Mill Tail Creek):
A new single-track railroad bridge will have to be constructed. Private undergrade access will have to be included.

M.P. 61.80 - Private grade crossing:
Alternate access from SR 618 available. Serves one house only.

M.P. 61.50 - 61.72 - 1°00′ curve right:
Any reduction of curvature would not be feasible on either side as curve is in the center of the town of Providence Forge.

M.P. 61.95 - Concrete arch with pipe liner, length is 71 feet, will have to be lengthened.

M.P. 62.32 - Rt. 618 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A double-track underpass will be required due to close proximity of US Rt. 60.

M.P. 62.55 - 62.66 - 1°04′ curve left:
It would be feasible to design a 0°30′ curve. Terrain conducive to this and will probably stay on right-of-way.

M.P. 62.85 - Private grade crossing, serving two families:
No alternate access available but could be connected to Rt. 618.

M.P. 63.64 - Private grade crossing:
No alternate access available. An underpass will probably be required if access deemed necessary.

M.P. 63.99 - Bridge over Schiminoe Creek:
A single-track railroad bridge will be required.

M.P. 64.01 - PS for industrial track No. 3009 on south side, length is 1171 feet:
Railroad will have to determine if track is necessary.

M.P. 64.27 - SR 615 grade crossing:
Traffic control devices consist of passive warning signs. A two-track grade separation structure may be required.

M.P. 64.41 - 64.74 - Private road on south side of right-of-way

M.P. 65.36 - 65.86 - Five bridges over branches of the Chickahominy River. A new single-track bridge will be required for each branch if branches cannot be consolidated.

M.P. 66.04 - PS to industrial track No. 542 on south side, length is 747 feet:
Railroad will have to determine if track can be retired.

M.P. 66.20 - Bridge over Opossum Creek:
A new single-track railroad bridge will be required.

M.P. 66.45 - SR 609 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A double-track grade separation structure will be required.

M.P. 66.99 - SR 106 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A grade separation structure could be combined with the SR 609 facility at M.P. 66.45.

M.P. 66.94 - 67.48 - 0°30′ curve:
No problem.

M.P. 67.75 - Private grade crossing:
No alternate access available but appears feasible from Rt. 600 on north side of right-of-way.

M.P. 68.55 - Private grade crossing:
No alternate access available. Double-track grade separation required if access deemed necessary.

M.P. 69.03 - 70.03 - 1°00′ curve left:
Terrain not conducive to reducing curvature.

M.P. 69.25 - Private grade crossing:
No alternate access available. Double-

track grade separation required if access deemed necessary.

M.P. 69.68 - Double concrete arch, length is 36.5 feet: Will need lengthening or a new single-track bridge constructed.

M.P. 70.05 - Bridge over creek: New single-track structure will be required.

M.P. 70.15 - Bridge over White Oak Swamp: New single-track structure will be required.

M.P. 71.26 - White Oak Rd. (Rt. 156) grade crossing: Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A double-track grade separation structure will be required.

M.P. 71.43 - 10′ concrete flat top culvert: New structure will be required.

M.P. 71.71 - 6′ rail top culvert: New structure will be required.

M.P. 71.62 - 73.07 - 0°40′ curve right: Not feasible to reduce curvature unless all tracks are relocated in a northerly direction. Terrain does not appear conducive for such a shift.

M.P. 72.78 - Bridge over White Oak Swamp: A new single-track structure will be required for a high speed track.

M.P. 73.26 - Bridge over White Oak Swamp:
A new single-track structure will be required for a high speed track.

M.P. 73.87 - Bridge over White Oak Swamp:
A new single-track structure will be required for a high speed track.

Note: There is a potential to either relocate the channel for White Oak Swamp in a northerly direction or keep track south of the loop made by the stream, thereby eliminating the need for structures at M.P. 73.26 and 73.87.

M.P. 74.48 - 74.80 - 1°00′ curve left:
A 0°30′ curve may be constructed if a survey indicates minimal disruption in the Village of Poplar Springs.

M.P. 74.68 - Poplar Springs Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A two-track grade separation structure will be required.

M.P. 74.88 - Bridge over White Oak Swamp:
A new single-track structure will be required for a high speed track.

M.P. 75.36 - Private grade crossing to Henrico County police shooting range:
Access will have to be maintained.
Recommend a two-track underpass in line with La France Road approximately 500 feet

west of existing crossing, due to Richmond drag strip complex.

M.P. 76.20 - 81.39 - Double track to beginning of Fulton Yard in Richmond and the end of this study.

M.P. 76.21 - I-295 overpass:
Clearance appears feasible for a high speed track.

M.P. 76.82 - Beulah Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. Richmond International airport on north side of track. Further study will be necessary to determine ultimate solution.

M.P. 77.93 - 78.12 - Roadway on south side of right-of-way:
Appears feasible to remove, if deemed necessary.

M.P. 78.40 - Charles City Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A single-track grade separation structure will be required.

M.P. 78.48 - PS to industrial track No. 3049:
Railroad will determine if business is adequate to maintain service. Also, industrial track Nos. 3050, 3051, and 3057 go off track No. 3049.

M.P. 79.00 - Miller Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A single-track grade separation structure will be required if access at this location is deemed necessary. Recommend closure.

M.P. 79.24 - Laburnum Av. overpass:
Ample room for an additional track on south side but may require some track realignment.

M.P. 79.50 - PS for industrial track No. 3001 on south side, includes switches to industrial track Nos. 3002 and 3003:
Railroad will have to determine if traffic is sufficient to maintain service.

M.P. 79.65 - PS for industrial track No. 2969 on south side leading into several tracks for A. H. Robins Company facilities.

M.P. 80.59 - 80.69 - 2°00′ curve left:
In yard limits and not feasible to deduce curvature.

M.P. 80.91 - 8′ brick arch (almond Creek), length is 126 feet:
Appears adequate for additional high speed track.

M.P. 80.97 - Darbytown Rd. overpass:
Adequate room for high speed track but may require some realignment of CSX trackage.

M.P. 81.38 - Undergrade highway crossing:
Adequate room for high speed track but may require some realignment of CSX trackage.

Existing Alignment Scenario
Allowable Speeds
Maximum Speed of 150 MPH

Milepost	Route Miles	Restriction	Speed MPH
11.5 - 14.36	2.86	Yard limits	20
14.36 - 28.33	13.97		150
28.33 - 29.16	0.83	0°44′ curve	134
29.16 - 29.86	0.70		150
29.86 - 30.23	0.37	0°56′ curve	119
30.23 - 31.92	1.69		150
31.92 - 32.19	0.27	2°00′ curve	80
32.19 - 32.81	0.62		150
32.81 - 33.09	0.28	2°00′ curve	80
33.09 - 36.02	2.93		150
36.02 - 36.77	0.75	1°00′ curve	113
36.77 - 37.00	0.23		150
37.00 - 38.26	1.26	1°00′ curve	113
38.26 - 40.84	2.58		150
40.84 - 41.17	0.33	1°00′ curve	113
41.17 - 42.93	1.76		150
42.93 - 43.24	0.31	1°00′ curve	113
43.24 - 46.32	3.08		150
46.32 - 46.63	0.31	2°00′ curve	80
46.63 - 46.84	0.21		150
46.84 - 47.14	0.30	2°00′ curve	80
47.14 - 47.36	0.22		150
47.36 - 47.60	0.24	2°00′ curve	80
47.60 - 47.79	0.19		150
47.79 - 48.26	0.47	1°52′ curve	84
48.26 - 49.24	0.98		150
49.24 - 49.80	0.56	3°00′ curve	50
49.80 - 50.19	0.39		150
50.19 - 50.65	0.46	1°55′ curve	83
50.65 - 50.82	0.17		150
50.82 - 51.25	0.43	1°10′ curve	105
51.25 - 52.69	1.44		150

Existing Alignment Scenario
Allowable Speeds
Maximum Speed of 150 MPH
(continued)

Milepost	Route Miles	Restriction	Speed MPH
52.69 - 52.97	0.28	2°30′ curve	72
52.97 - 53.18	0.21		150
53.18 - 53.45	0.27	3°04′ curve	50
53.45 - 53.51	0.06		150
53.51 - 54.00	0.49	3°00′ curve	50
54.00 - 56.04	2.04		150
56.04 - 56.45	0.41	1°00′ curve	113
56.45 - 61.50	5.05		150
61.50 - 61.72	0.22	1°00′ curve	113
61.72 - 62.55	0.83		150
62.55 - 62.66	0.11	1°04′ curve	112
62.66 - 69.03	6.37		150
69.03 - 70.03	1.00	1°00′ curve	113
70.03 - 71.62	1.59		150
71.62 - 73.07	1.45	1°20′ compound curve	99
73.07 - 74.48	1.41		150
74.48 - 74.80	0.32	1°00′ curve	113
74.80 - 81.25	6.45		150
81.25		Yard limits	20

Estimate of Costs
Existing Alignment Scenario
Non-Electrified

Item	Cost Per Mile	Route Miles	Cost
Clearing, grading, drainage, subgrade	$ 73,000	70	$ 5,110,000
Track	850,000	70	59,500,000
Signal	250,000	70	17,500,000
Utility Relocation	214,000	70	14,980,000
Fencing (both sides)	38,000	140	5,320,000
Bridges:			
Grade Separations			19,320,000
Railroad Bridges			16,500,000
Highway Bridges			33,770,000
Misc. Items			6,000,000
Total			178,000,000
+25% Contingency			44,500,000
Grand Total			$222,500,000

RIGHT-OF-WAY NOT INCLUDED

Electrification Estimate
Existing Alignment Scenario

Item	Cost Per Mile	Cost
Electrification	$700,000	$ 49,000,000
Overhead bridge modification		12,000,000
Total		$ 61,000,000
+25% Contingency		15,250,000
Grand Total		$ 76,250,000

Assumptions and Notes for Estimate
Existing Alignment Scenario

1. Utilized south side of right-of-way as much as deemed feasible, maintaining a minimum of 20 feet from nearest main line where feasible.

2. In general, minimum right-of-way is 100 feet.

3. Speeds based on FRA curve speeds, with 3" unbalanced super elevation.

4. Concrete ties used.

5. No cross-sections were plotted and grading costs are general railroad approved figures.

6. Right-of-way costs are not included.

7. No CSX track relocation costs or retirement of industrial spurs are included.

8. 25% contingency costs are for engineering and ultimate design factors.

9. Signal costs include CSX track changes and traffic control systems.

10. Miscellaneous items include station work, retirement of structures, track drainage facilities, highway relocations, stations and parallel roadways.

11. Estimated costs are based on approved railway procedure.

12. No costs included for stations or terminals.

150 MPH Scenario
Analysis of Problem Areas

M.P. 11.5± - 14.36 - Classification Yards for Old Point Junction in Newport News:
CSX will have to determine if room is available for separate track. From the right-of-way and track map, there is a small area on the south side, east of Mercury Blvd., where there is insufficient room for a third main line.

M.P. 14.24 - Center Av. underpass:
There are four tracks over bridge with approximately 40 feet on south side. Part of the bridge has been retired in place and room is available for an additional track.

M.P. 14.97 - Main St. (Rt. 152) underpass:
There are two tracks over bridge with a portion of bridge retired in place. However, width is insufficient for third main line and will have to be widened or replaced.

M.P. 15.37 - Switch on south side to various facilities:
Business interests will decree whether track can be eliminated.

M.P. 16.53 - End of passing track:
Single track for next 5.9 miles.

M.P. 16.55 - Harpersville Rd. grade crossing:
Traffic control devices consist of automatic flashing light signals with

short arm gates. Double-track grade separation required.

M.P. 17.55 - 10′ brick and concrete arch structure for Causey's Mill Pond:
Structure will have to be lengthened or rebuilt for high speed tracks.

M.P. 17.58 - 8′ x 8′ concrete box underpass:
Will have to be lengthened or rebuilt for high speed tracks.

M.P. 17.74 - J. Clyde Morris Blvd. overpass:
A survey will be necessary to determine adequacy of clearance for an additional track.

M.P. 17.67 - 19.52 - A private road is on south side of right-of-way and would have to be relocated.

M.P. 19.55 - Private grade crossing:
Should be closed and alternate access provided at Bell King Road, M.P. 19.77, including a parallel drive on north side of right-of-way.

M.P. 19.77 - Bell King Rd.:
Recommend an underpass due to close proximity of US Rt. 60. Underpass will have to include CSX main line.

M.P. 20.01 - 20.50 - Private road on south side of right-of-way will require relocation.

M.P. 20.21 - 20.38 - 0°40′ curve left, 867 feet long: 0°30′ curve can be constructed with minimal effort.

M.P. 20.47 - Oyster Point Rd. overpass: Adequate room to add a high speed track.

M.P. 20.87 - 12′ concrete arch structure for Deep Creek: Will require lengthening or reconstruction for high speed track.

M.P. 22.0 - Eastwood Bland Connection Rd. overpass: Should be adequate for an additional high speed track.

M.P. 22.30 - 22.65 - Private road on south side of right-of-way: Will require relocation.

M.P. 22.41 - 35.24 - Second main line included on south side

M.P. 22.76 - Point of switch to two industrial sidings, Nos. 487 and 2921, on south side: Track No. 487 would negate an additional high speed track on south side of right-of-way. Interstate 64 would deter any shifting of track in a northerly direction.

M.P. 22.84 - Rt. 173 overpass: This structure further complicates the installation of a high speed track, as it spans industrial sidings, Nos. 487 and 2921, as noted at M.P. 22.76.

M.P. 23.3 - Deck girder bridge over Stony Creek: New single-track structure will be required.

M.P. 25.3 - Industrial Park Dr. grade crossing: Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A grade separation structure will be required.

M.P. 25.51 - Point of switch to track No. 490: Track retired in place and can be removed.

M.P. 26.00 - Rt. 105 overpass: Should be adequate for an additional track.

M.P. 26.43 - 12′ arch for Warwick River: Will require widening or reconstruction for a high speed track.

M.P. 26.49 - PS for passing siding No. 493 on south side, length is 5661 feet

M.P. 26.73 - PS for Ft. Eustis track No. 491 on south side off passing siding No. 493

M.P. 26.83 - PS for storage track No. 492, length is 3577 feet, on south side off passing siding No. 493

M.P. 27.38 - PS for track No. 494 off storage track on south side

M.P. 27.52 - Yorktown Rd. grade crossing: Traffic control devices consist of train activated automatic flashing light

signals. Grade separation structure will be required.

M.P. 27.53 - PS for track No. 495 off south side of passing siding No. 493 with track No. 2104 coming off track No. 495.

M.P. 27.62 - Elmhurst Dr. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals and short arm gates. Grade separation structure will be required.

Note: The section of track from M.P. 26.49 to 27.77 will require additional study to determine if any of sidings Nos. 493, 491, 492, 494, 495, and 2104 can be removed. Also, it will have to be determined if the grade crossings of Yorktown Road and Elmhurst Drive can be combined, thereby closing one crossing and eliminating the need for two new grade separation structures.

M.P. 28.06 - Private grade crossing:
Either alternate access or an underpass will be necessary if required to maintain access.

M.P. 28.33 - 29.16 - 0°44′ curve left:
Any attempt to obtain a 0°30′ curve left will require the relocation of approximately 3000 feet of US Rt. 60.

M.P. 29.86 - 30.23 - 0°56′ curve right:
To obtain a 0°30′ curve would require the relocation of portions of SR 168, the two

main lines, and Dow Chemical Track No. 2791.

M.P. 30.0 - 30.81 - Private road on right-of-way will have to be relocated

M.P. 30.60 - PS to Dow Chemical Track No. 2791, on south side of right-of-way

M.P. 31.92 - 45.83 - A detailed survey, economical analysis, environmental review, and other impact statements will be required to determine the feasibility of relocation the track in this area to bypass the Williamsburg historical areas and related businesses.

Pro. M.P. 32.26 - SR 143 interchange

Pro. M.P. 32.70 - King Creek

Pro. M.P. 33.47 - Whiteman Swamp Stream

Pro. M.P. 34.00 - SR 641

Pro. M.P. 34.54 - Jones Pond

Pro. M.P. 35.42 - Colonial National Historical Parkway

Pro. M.P. 35.76 - Stream

Pro. M.P. 36.02 - SR 716

Pro. M.P. 36.67 - Queen Creek

Pro. M.P. 37.62 - SR 143 Interchange

Pro. M.P. 38.11 - Stream

Pro. M.P. 38.40 - SR 713

Pro. M.P. 38.76 - SR 645

Pro. M.P. 39.88 - Stream

Pro. M.P. 40.08 - Access to Schenck Estates

Pro. M.P. 40.36 - SR 602

Pro. M.P. 41.30 - SR 602

Pro. M.P. 41.87 - SR 646

Pro. M.P. 43.00 - Skimino Creek

Pro. M.P. 43.71 - Unnamed Roadway

Pro. M.P. 44.50 - Roadway

Pro. M.P. 44.65 - SR 602

Pro. M.P. 44.85 - Roadway

M.P. 46.0 - 51.0 - There are seven curves in this five-mile area, varying from 1°10′ to 3°00′. A detailed survey would be required to determine if it would be economically feasible to realign trackage to have a maximum 0°30′ curve. This is engineeringly feasible but the survey would determine the best alignment.

M.P. 51.02 - Forge Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals

with short arm gates. Double-track grade separation structure will be required.

M.P. 51.0 - 52.0 - Publicly used road on right-of-way:
Right of individuals to use roadway will have to be established and legally dealt with.

M.P. 52.35 - Rt. 601 underpass:
Will have to be lengthened or reconstructed for high speed track.

M.P. 52.51 - Diascund Creek bridge:
Single-track bridge will be required for high speed track.

M.P. 52.69 - 55.49 - Engineeringly feasible to realign trackage to have a maximum of 0°30′ curve replacing the three curves of 2°30′, 3°00′, and 3°04′, thereby allowing an operating speed of 150 mph. A detailed survey will be required to determine economical feasibility.

M.P. 55.49 - Private grade crossing to Chickahominy Lake:
Investigate alternate access.

M.P. 56.04 - 56.45 - 1°00′ curve left:
Any potential CSX shift would be minimal due to location of US Rt. 60 on the north side. A 0°30′ curve can be constructed on south side of right-of-way without disturbing CSX track.

M.P. 56.57 - Private grade crossing:
There does not appear to be an alternate

access. An underpass will be required, if access deemed necessary, due to close proximity of US Rt. 60 on north side.

M.P. 56.93 - Private grade crossing:
There does not appear to be an alternate access unless a parallel access road is constructed.

M.P. 57.08 - Brick arch and 96" liner plate:
Both drainage structures will have to be lengthened.

M.P. 57.15 - Public grade crossing, SR 647, leading to Osborn Landing:
Access will have to be maintained.

M.P. 57.35 - Private grade crossing leading to several houses:
Access will have to be maintained.

M.P. 57.70 - Rt. 650 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. Access will have to be maintained with a grade separation structure.

M.P. 57.95 - Private grade crossing:
No alternate access available.

M.P. 57.86 - 58.14 - 0°30′ curve right:
No problem.

M.P. 58.55 - Private grade crossing to state game farm:
Access will have to be maintained.

M.P. 58.65 - 61.13 - Double track

M.P. 58.72 - Private grade crossing:
No alternate access available.

Note: The private and public grade crossings at M.P. 56.57, 56.93, 57.15, 57.35, 57.70, 57.95, 58.55, and 58.72 could be consolidated with one underpass if a parallel access road could be constructed. The structure would have to be an underpass due to the close proximity of US Rt. 60.

M.P. 59.27 - 59.42 - 0°30′ curve left:
No problem.

M.P. 59.93 - PS to track No. 534 (passing track) on south side, length is 5805 feet:
(To stay on right-of-way, track No. 534 will have to be eliminated.)

M.P. 60.12 - Private farm crossing:
Alternate access may be available.

M.P. 60.53 - 60.74 - 0°20′ curve left:
No problem.

M.P. 60.80 - Rt. 602 grade crossing:
Traffic control devices consist of passive warning signs. A single-track grade separation structure will be required.

M.P. 60.98 - PS for track No. 536 on south side:
Two additional industry tracks, Nos. 2869 and 2939, lead from track No. 536.

M.P. 61.13 - 76.20 - Single track

M.P. 61.27 - SR 155 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A grade separation structure will be required. The structure could be used to close the Rt. 602 grade crossing at M.P. 60.80.

M.P. 61.54 - Deck plate girder bridge over Jones Run (Mill Tail Creek):
A new single-track railroad bridge will have to be constructed. Private under-grade access will have to be included.

M.P. 61.80 - Private grade crossing:
Alternate access from SR 618 available. Serves one house only.

M.P. 61.50 - 61.72 - 1°00' curve right:
Any reduction of curvature would not be feasible on either side as curve is in the center of the town of Providence Forge.

M.P. 61.95 - Concrete arch with pipe liner, length is 71 feet, will have to be lengthened

M.P. 62.32 - Rt. 618 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A double-track underpass will be required due to close proximity of US Rt. 60.

M.P. 62.55 - 62.66 - 1°04′ curve left:
It would be feasible to design a 0°30′ curve. Terrain conducive to this and will stay on right-of-way.

M.P. 62.85 - Private grade crossing, serving two families:
No alternate access available but could be connected to Rt. 618.

M.P. 63.64 - Private grade crossing:
No alternate access available. An underpass will probably be required if access deemed necessary.

M.P. 63.99 - Bridge over Schiminoe Creek:
A single-track railroad bridge will be required.

M.P. 64.01 - PS for industrial track No. 3009 on south side, length is 1171 feet:
Railroad will have to determine if track is necessary.

M.P. 64.27 - SR 615 grade crossing:
Traffic control devices consist of passive warning signs. A two-track grade separation structure may be required.

M.P. 64.41 - 64.74 - Private road on south side of right-of-way

M.P. 65.36 - 65.86 - Five bridges over branches of the Chickahominy River. A new single-track bridge will be required for each branch if branches cannot be consolidated.

M.P. 66.04 - PS to industrial track No. 542 on south side, length is 747 feet:
Railroad will have to determine if track can be retired.

M.P. 66.20 - Bridge over Opossum Creek:
A new single-track railroad bridge will be required.

M.P. 66.45 - SR 609 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A double-track grade separation structure will be required.

M.P. 66.99 - SR 106 grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A grade separation structure could be combined with the SR 609 facility at M.P. 66.45.

M.P. 66.94 - 67.48 - 0°30' curve:
No problem.

M.P. 67.75 - Private grade crossing:
No alternate access available but appears feasible from Rt. 600 on north side of right-of-way.

M.P. 68.55 - Private grade crossing:
No alternate access available. Double-track grade separation required if access deemed necessary.

M.P. 69.03 - 70.03 - 1°00′ curve left:
Terrain not conducive to reducing curvature.

M.P. 69.25 - Private grade crossing:
No alternate access available. Double-track grade separation required if access deemed necessary.

M.P. 69.68 - Double concrete arch, length is 36.5 feet:
Will need lengthening or a new single-track bridge constructed.

M.P. 70.05 - Bridge over creek:
New single-track structure will be required.

M.P. 70.15 - Bridge over White Oak Swamp:
New single-track structure will be required.

M.P. 71.26 - White Oak Rd. (Rt. 156) grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A double-track grade separation structure will be required.

M.P. 71.43 - 10′ concrete flat top culvert:
New structure will be required

M.P. 71.71 - 6′ rail top culvert:
New structure will be required.

M.P. 71.62 - 73.07 - 0°40′ curve right:
Not feasible to reduce curvature unless all tracks are relocated in a northerly

direction. Terrain does not appear conducive for such a shift.

M.P. 72.78 - Bridge over White Oak Swamp:
A new single-track structure will be required for a high speed track.

M.P. 73.26 - Bridge over White Oak Swamp:
A new single-track structure will be required for a high speed track.

M.P. 73.87 - Bridge over White Oak Swamp:
A new single-track structure will be required for a high speed track.

Note: There is a potential to either relocate the channel for White Oak Swamp in a northerly direction or keep track south of the loop made by the stream, thereby eliminating the need for structures at M.P. 73.26 and 73.87.

M.P. 74.47 - 74.80 - 1°00′ curve left:
A 0°30′ curve may be constructed if a survey indicates minimal disruption in the Village of Poplar Springs.

M.P. 74.68 - Poplar Springs Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A two-track grade separation structure will be required.

M.P. 74.88 - Bridge over White Oak Swamp:
A new single-track structure will be required for a high speed track.

M.P. 75.36 - Private grade crossing to Henrico County police shooting range:
Access will have to be maintained. Recommend a two-track underpass in line with La France Road approximately 500 feet west of existing crossing, due to Richmond drag strip complex.

M.P. 76.20 - 81.39 - Double track to beginning of Fulton Yard in Richmond and the end of this study

M.P. 76.21 - I-295 overpass:
Appears feasible for a high speed track.

M.P. 76.82 - Beulah Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. Richmond International airport on north side of track. A three-track grade separation structure will be required if closure not feasible.

M.P. 77.93 - 78.12 - Roadway on south side of right-of-way:
Appears feasible to remove, if deemed necessary.

M.P. 78.40 - Charles City Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A single-track grade separation structure will be required.

M.P. 78.48 - PS to industrial track No.3049:
Railroad will determine if business is adequate to maintain service. Also,

industrial track Nos. 3050, 3051, and 3057 go off track No. 3049.

M.P. 79.00 - Miller Rd. grade crossing:
Traffic control devices consist of train activated automatic flashing light signals with short arm gates. A single-track grade separation structure will be required if access at this location is deemed necessary. Recommend closure.

M.P. 79.24 - Laburnum Av. overpass:
Ample room for an additional track on south side but may require some track realignment.

M.P. 79.50 - PS for industrial track No. 3001 on south side, includes switches to industrial track Nos. 3002 and 3003:
Railroad will have to determine if traffic is sufficient to maintain service.

M.P. 79.65 - PS for industrial track No. 2969 on south side leading into several tracks for A. H. Robins Company facilities

M.P. 80.59 - 80.69 - 2°00′ curve left:
In yard limits and not feasible to deduce curvature.

M.P. 80.91 - 8′ brick arch (Almond Creek), length is 126 feet:
Appears adequate for additional high speed track.

M.P. 80.97 - Darbytown Rd. overpass:
Adequate room for high speed track but may require some realignment of CSX trackage.

M.P. 81.38 - Undergrade highway crossing:
Adequate room for high speed track but may require some realignment of CSX trackage.

Estimate of Costs
150 MPH Scenario
Non-Electrified

Item	Cost per Mile On R/W	Cost per Mile Off R/W	On R/W 62.2 Miles	Off R/W 7.80 Miles
Clearing, grading drainage, subgrade	$ 73,000	$138,500	$ 4,500,600	$ 1,080,300
Track	850,000	850,000	52,870,000	6,630,000
Signal	250,000	250,000	15,550,000	1,950,000
Utility Relocation	214,000	13,400	13,310,800	104,500
Fencing (Both sides)	38,000	38,000	4,727,200	592,800
Bridges:				
Grade Separations			24,680,000	
Railroad Bridges			16,500,000	
Highway Bridges			33,770,000	
Misc. Items			13,050,000	
			$165,948,000	$ 10,357,600
Total				$176,306,200
25% Contingency				44,076,600
Grand Total				$220,382,800

RIGHT-OF-WAY NOT INCLUDED

Electrification Estimate
150 MPH Scenario

Item	Cost per Mile	On R/W 62.2 Miles	Off R/W 7.80 Miles
Electrification	$700,000	$43,540,000	$5,460,000
Overhead Bridge Modification		12,000,000	
		$55,540,000	$5,460,000
Total		$61,000,000	
25% Contingency		15,250,000	
Grand Total		$76,250,000	

Summary

In this preliminary engineering feasibility study of a high speed track between Richmond and Newport News, two separate scenarios were reviewed, which have been referred to as the existing alignment scenario and the 150 MPH scenario, both shown and supported on attached sketches 1-19. The existing alignment scenario is estimated to cost $222,500,000 non-electrified, or $298,750,000 electrified. The 150 MPH scenario is estimated to cost $220,382,000 non-electrified, or $296,632,800 electrified. As may be noted, the estimated costs are virtually the same, and the main difference will be the cost of additional right-of-way. As may be noted on pages 39, 40, and 41 of this report, there are three areas where alignment relocation will eliminate much of the speed restrictions. These are between mileposts 31.92 and 45.83, mileposts 46.0 and 51.0, and mileposts 52.69 and 55.49. Much of the required right-of-way between mileposts 31.92 and 45.83 necessary to bypass the Williamsburg metropolitan area may be on state property, namely adjacent to Interstate 64 and other state highways.

Current and future legal and economic restrictions will ultimately determine which of the two scenarios will be the most desirable. From an engineering standpoint, both schemes will be feasible.

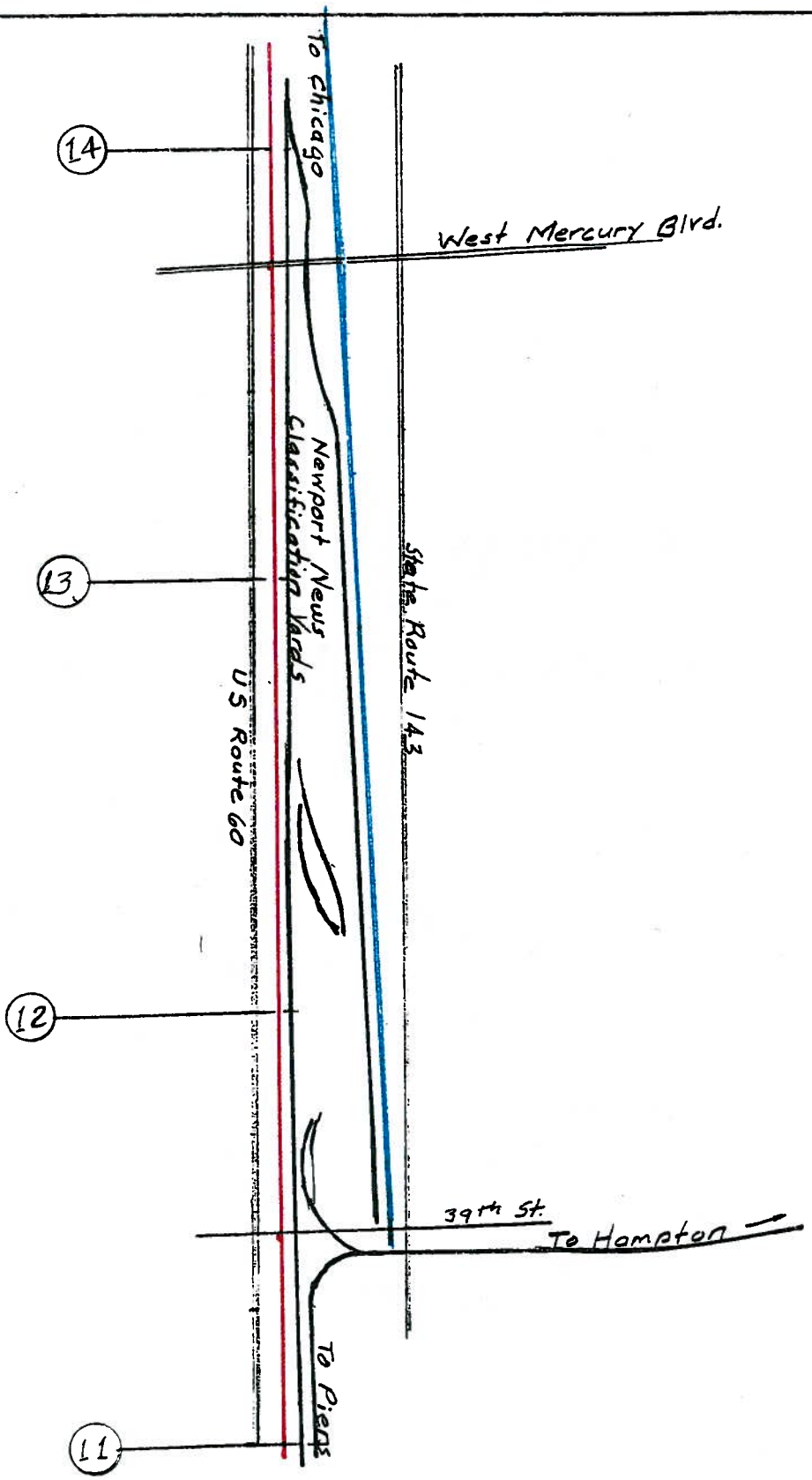
Proposed High Speed Passenger Track
Richmond, Virginia, to Newport News, Virginia
September 1993

Legend

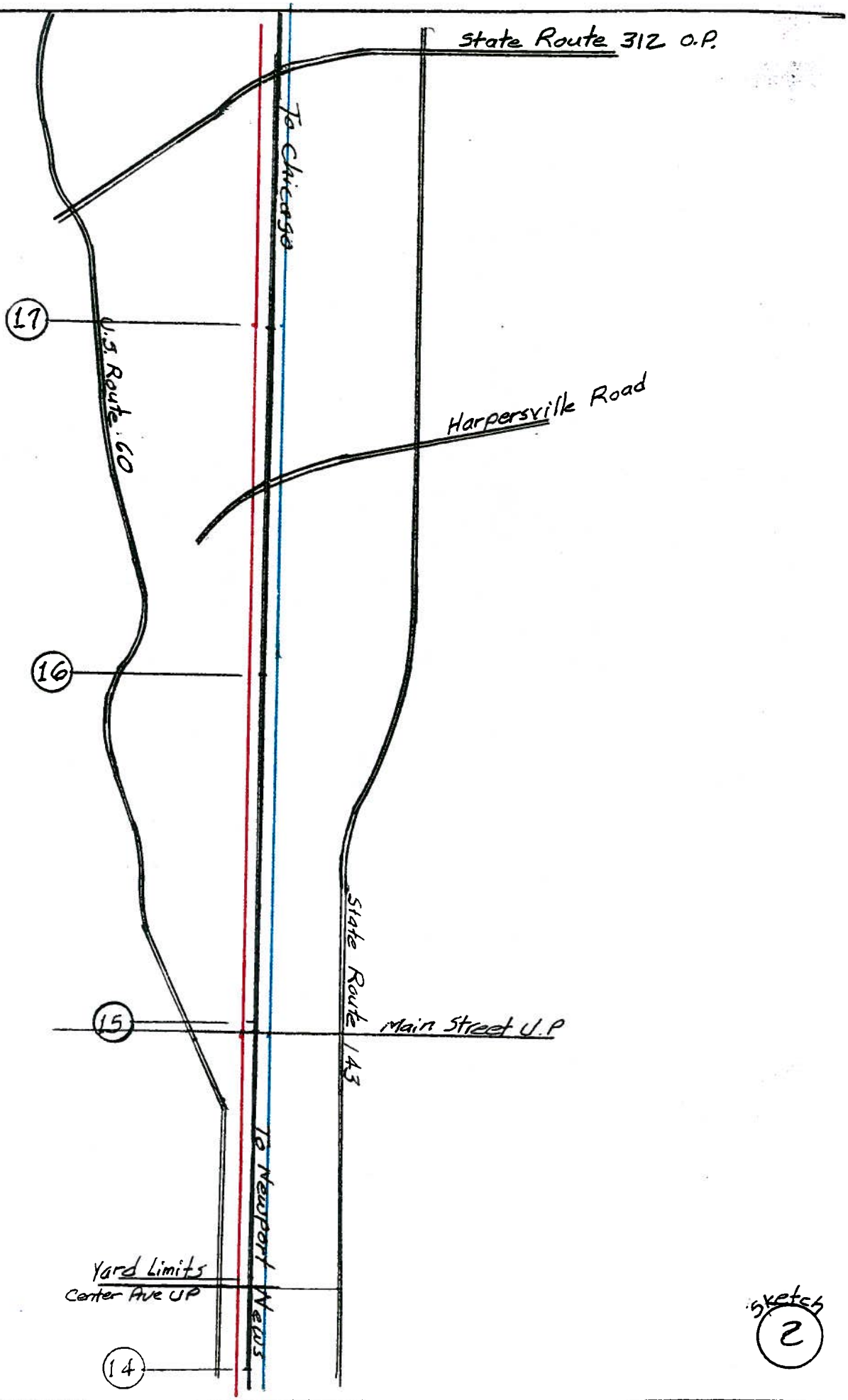
Additional High Speed Track
Existing Alignment Scenario

Additional High Speed Track
150 MPH Scenario

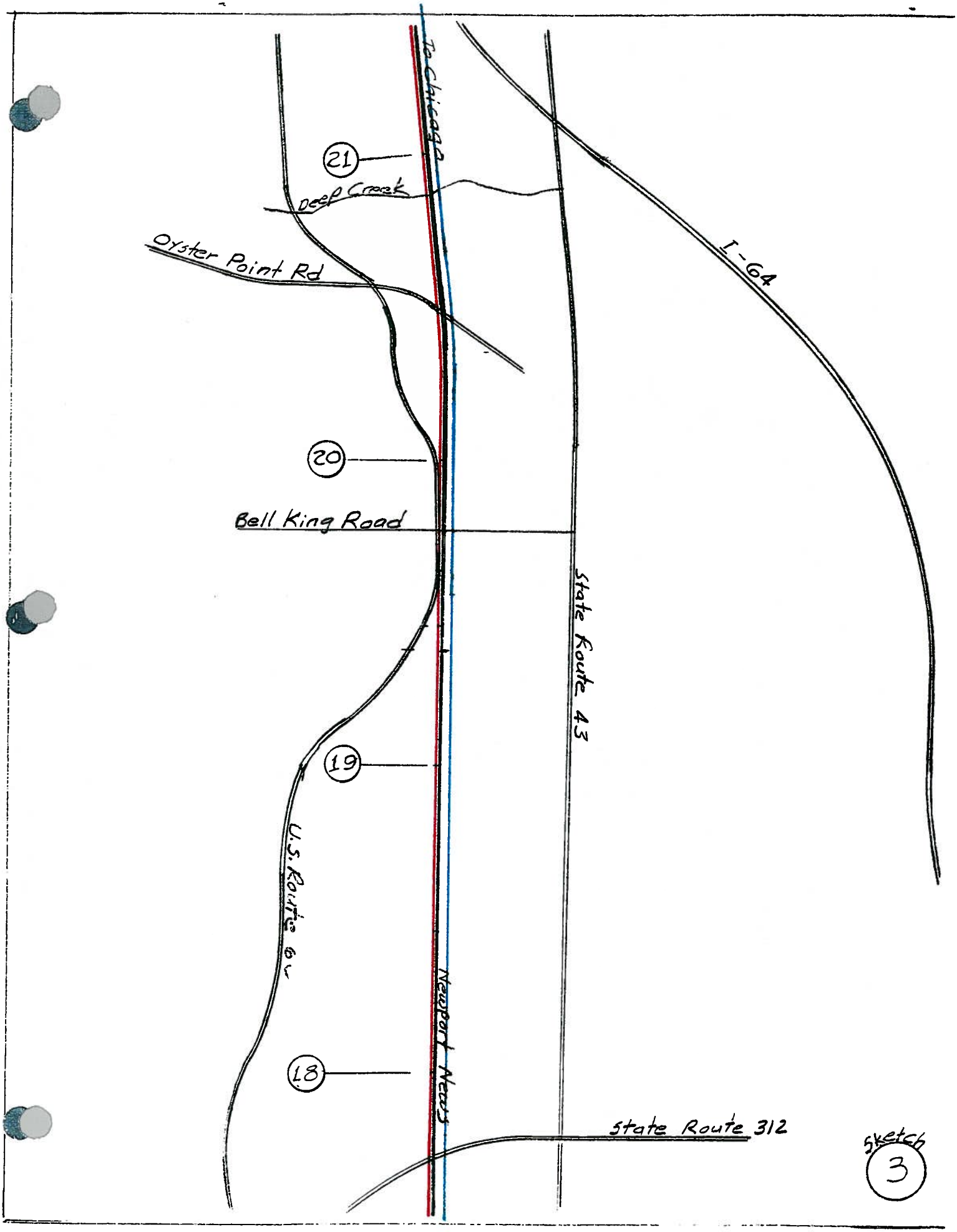
Existing Main Line


To Chicago
14
West Mercury Blvd.
State Route 143
Newport News Classification Yards
13
US Route 60
12
39th St.
To Hampton
To Piers
11

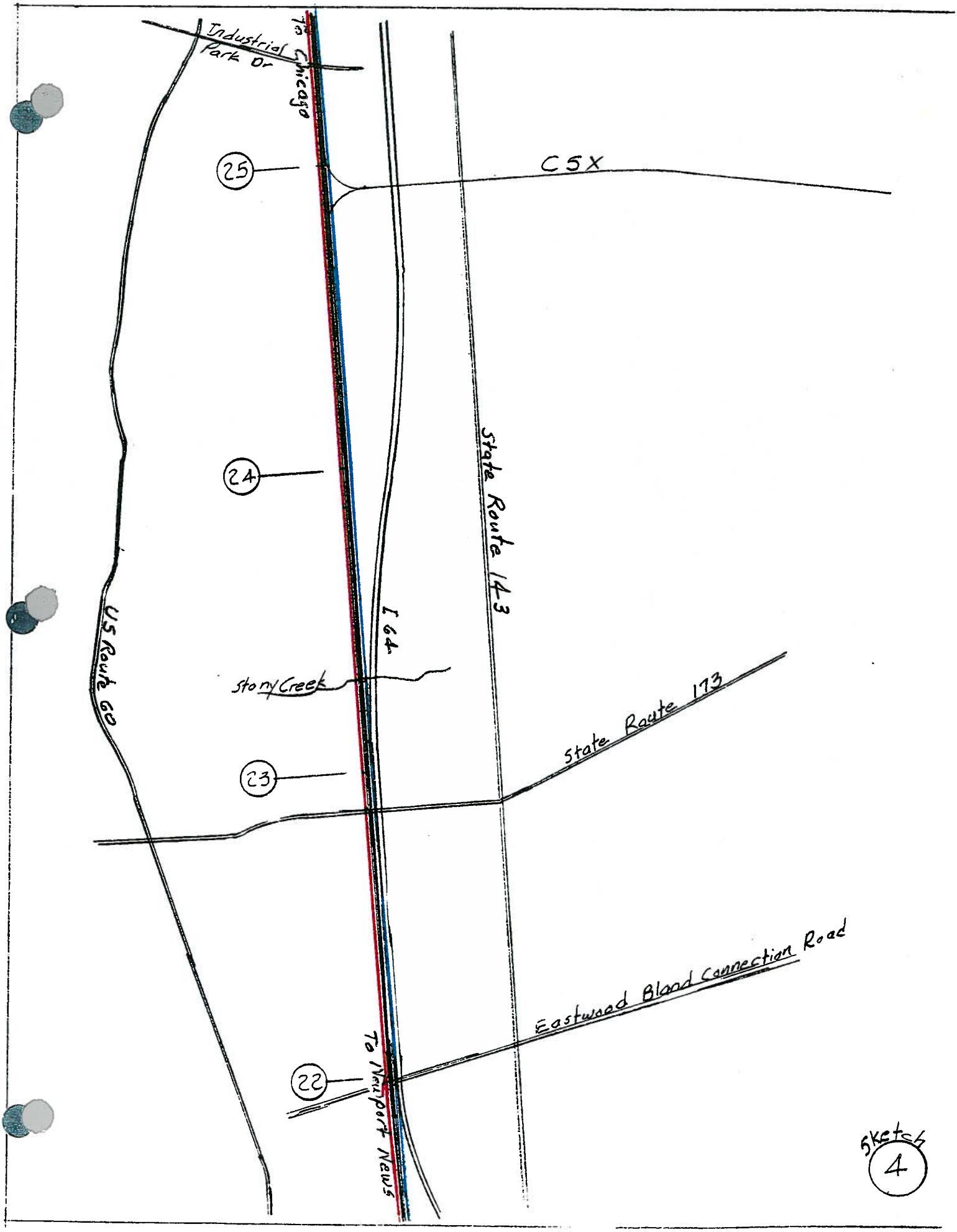
sketch 1


State Route 312 O.P.
To Chicago
17
U.S. Route 60
Harpersville Road
16
State Route 143
15
Main Street U.P
To Newport News
Yard Limits
Center Ave UP
14

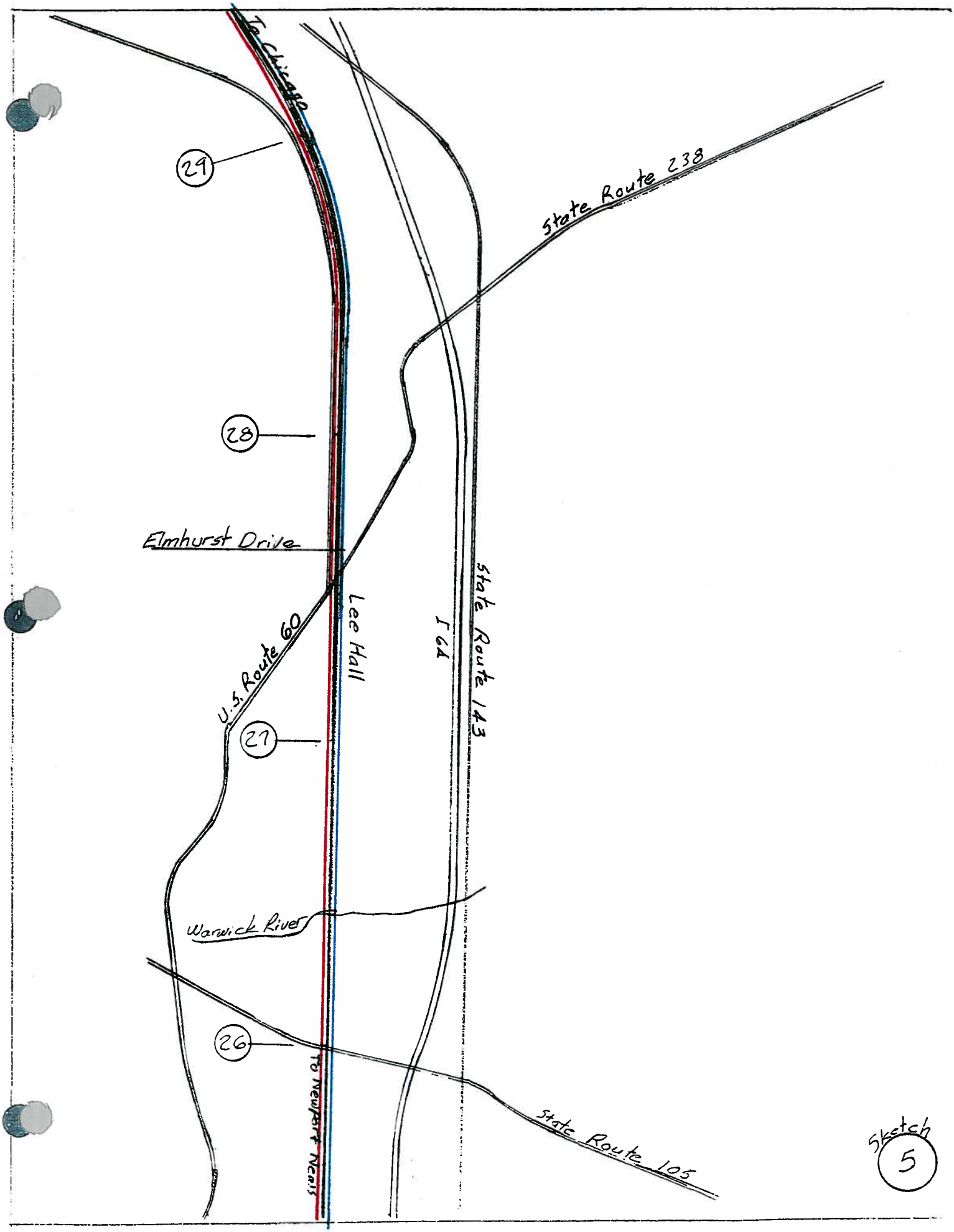
sketch 2


To Chicago
21
Deep Creek
Oyster Point Rd
I-64
20
Bell King Road
State Route 43
19
U.S. Route 60
Newport News
18
State Route 312

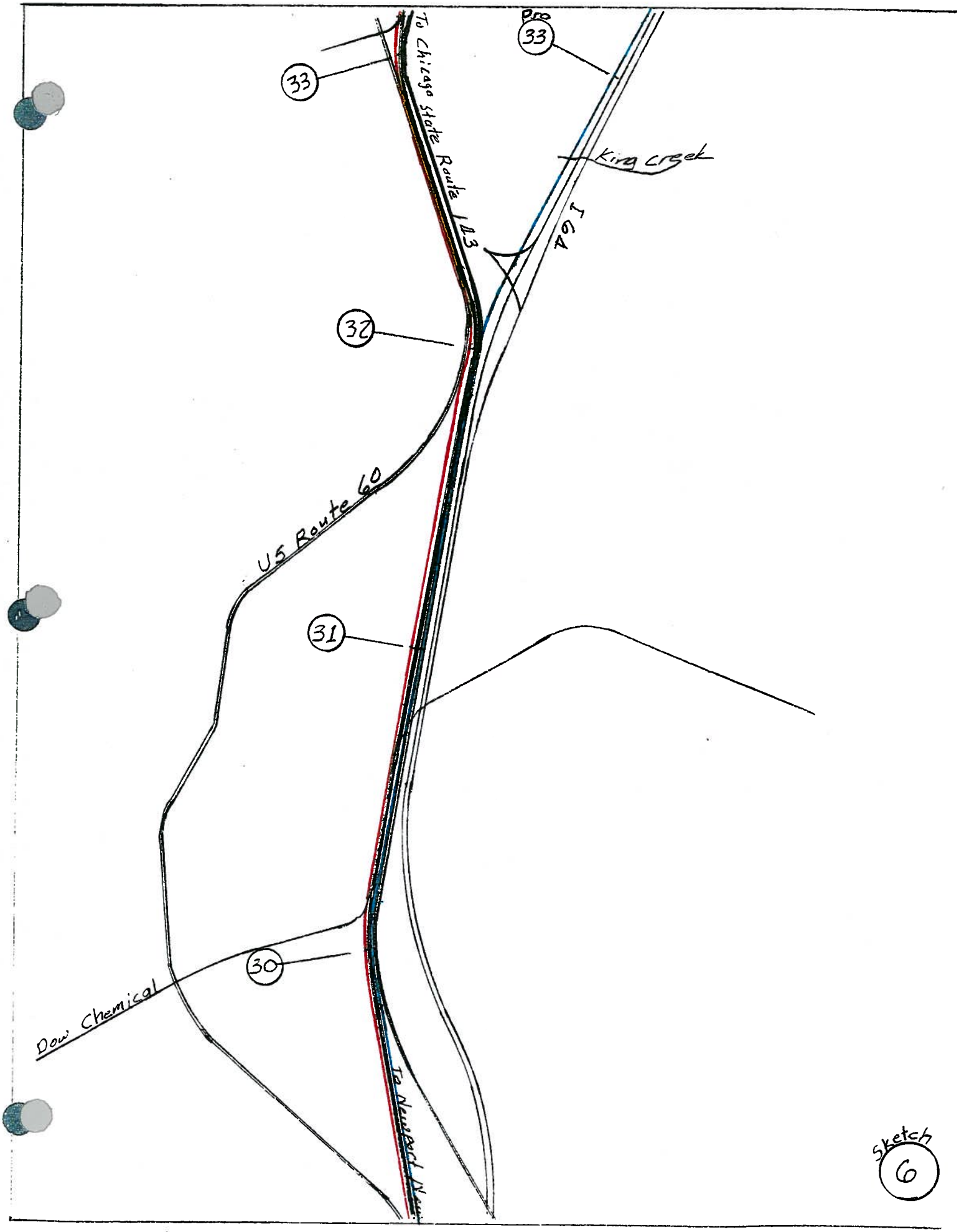
sketch 3

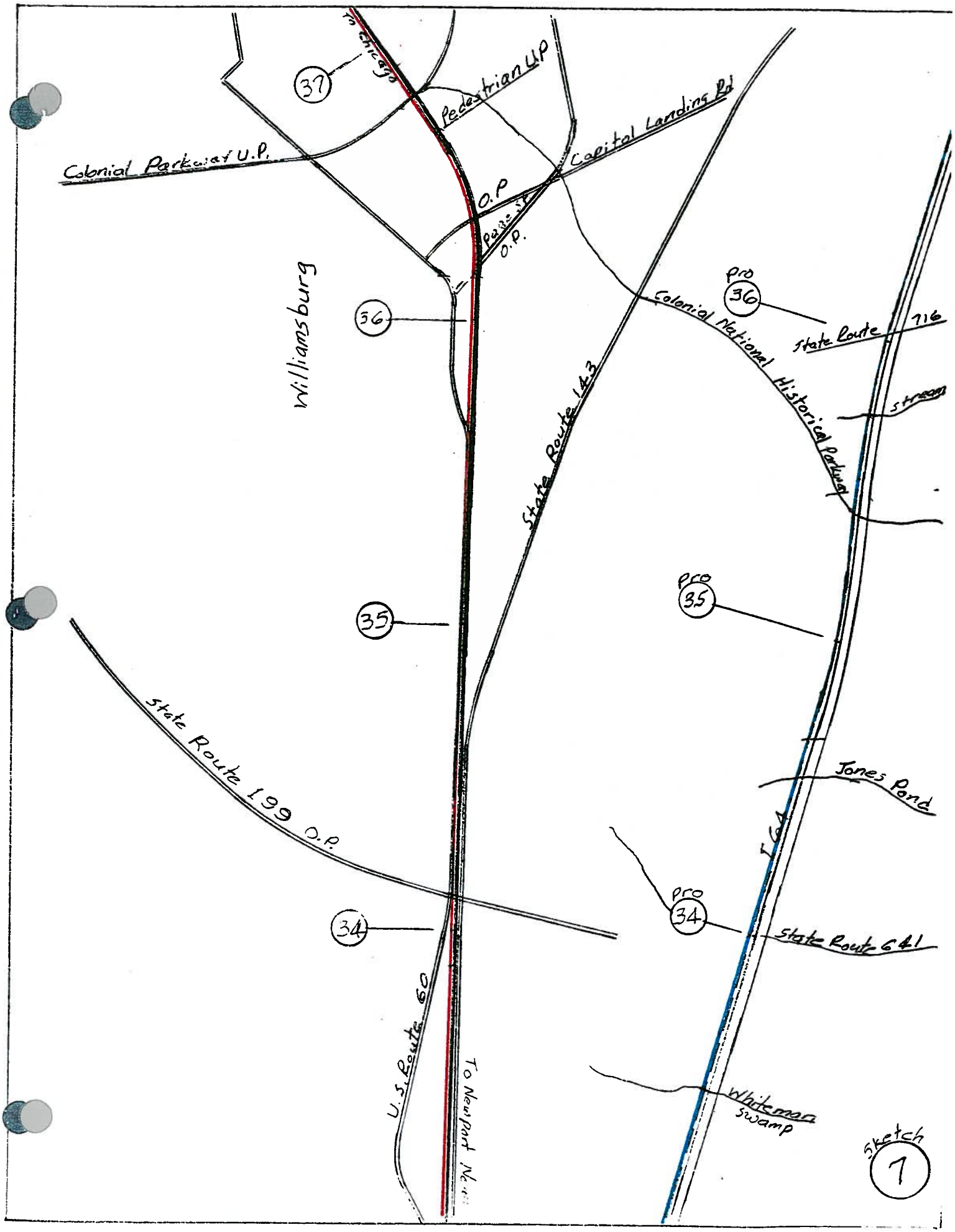

To Chicago
Industrial Park Dr
25
CSX
24
State Route 143
I 64
US Route 60
Stony Creek
State Route 173
23
Eastwood Blood Connection Road
22
To Newport News

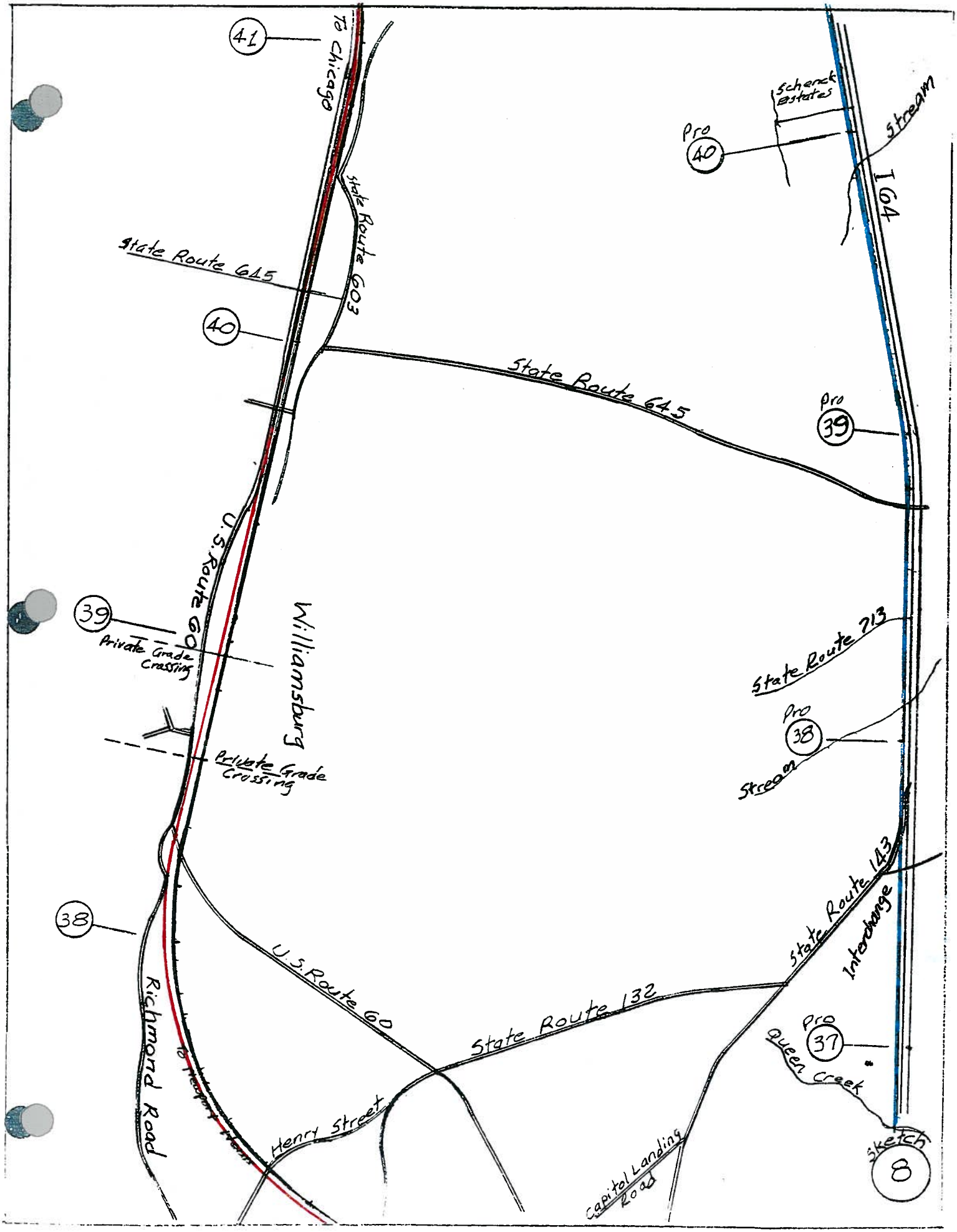
Sketch 4

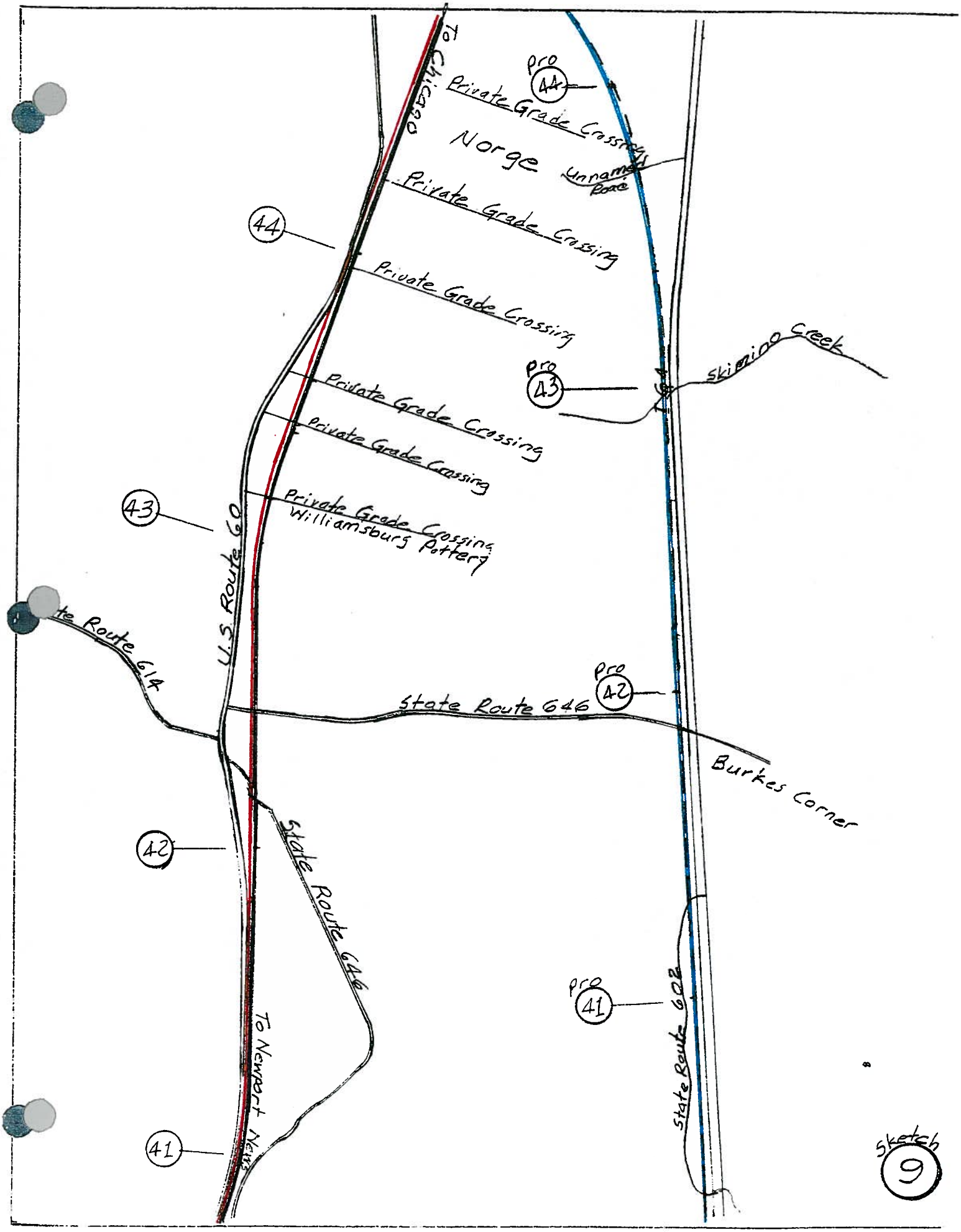

To Chicago
29
State Route 238
28
Elmhurst Drive
Lee Hall
I 64
State Route 143
U.S. Route 60
27
Warwick River
26
To Newport News
State Route 105

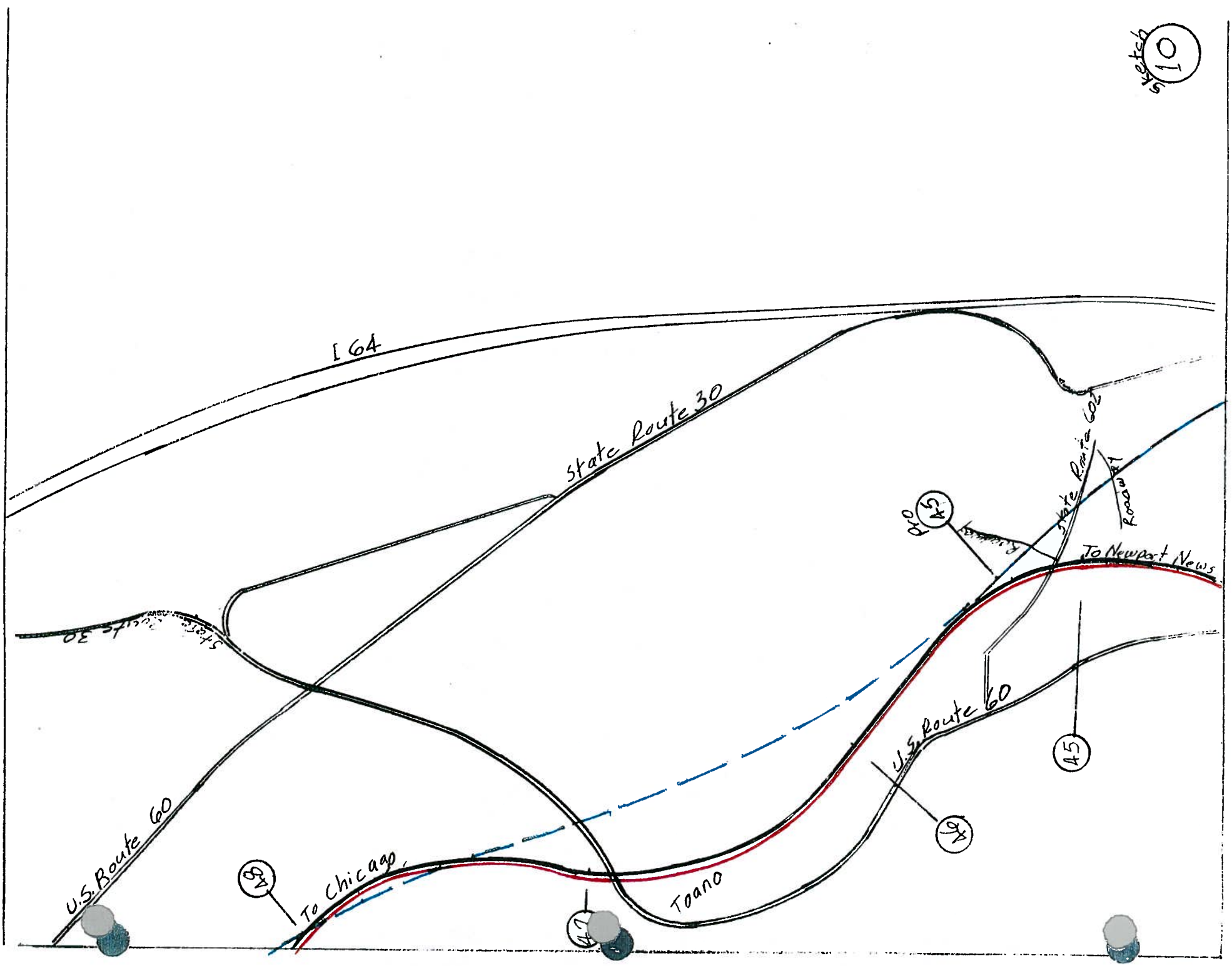
sketch 5

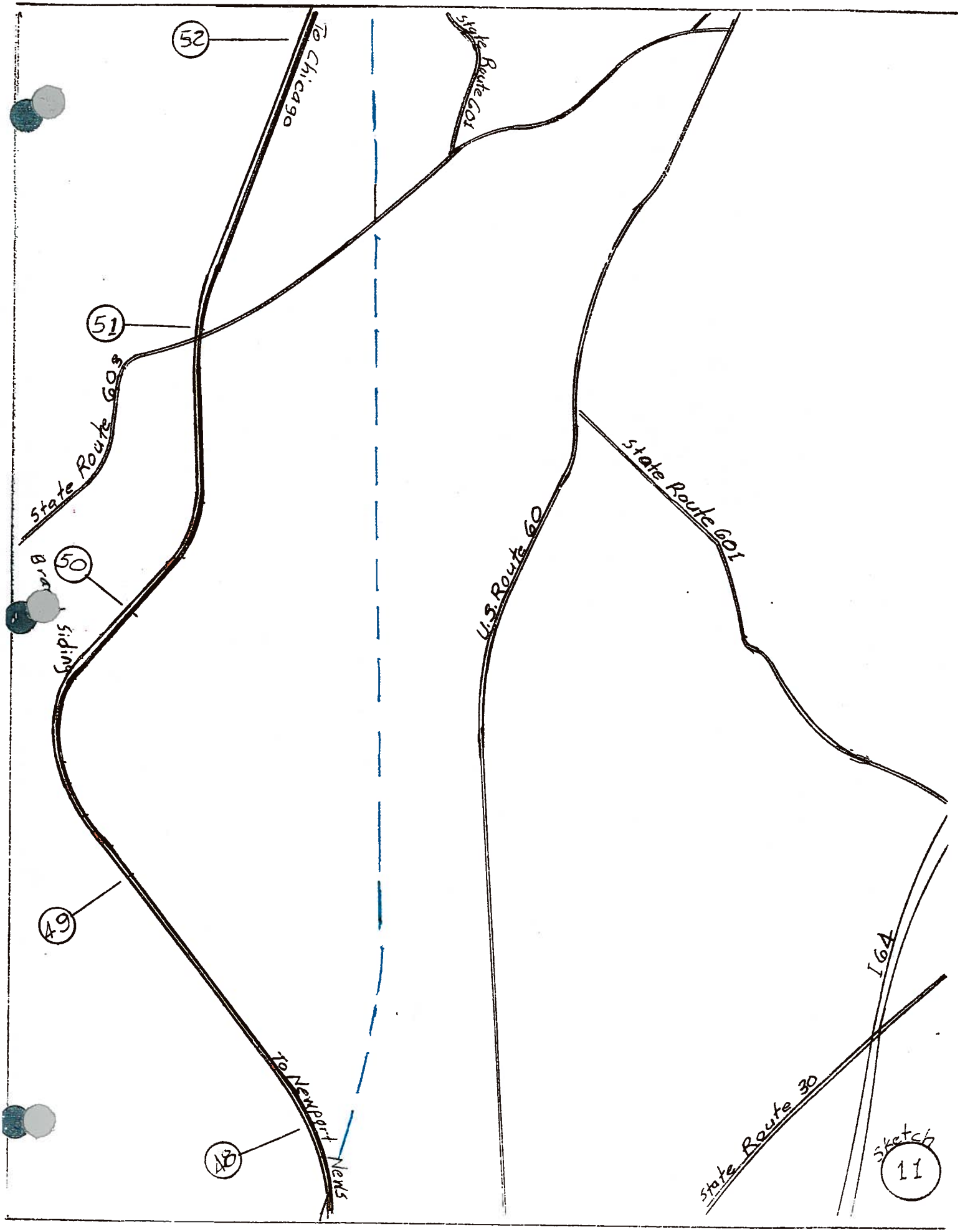

To Chicago State Route / U.S
33
33
Pro
King creek
I-80
32
US Route 60
31
30
Dow Chemical
To Newport
sketch
6

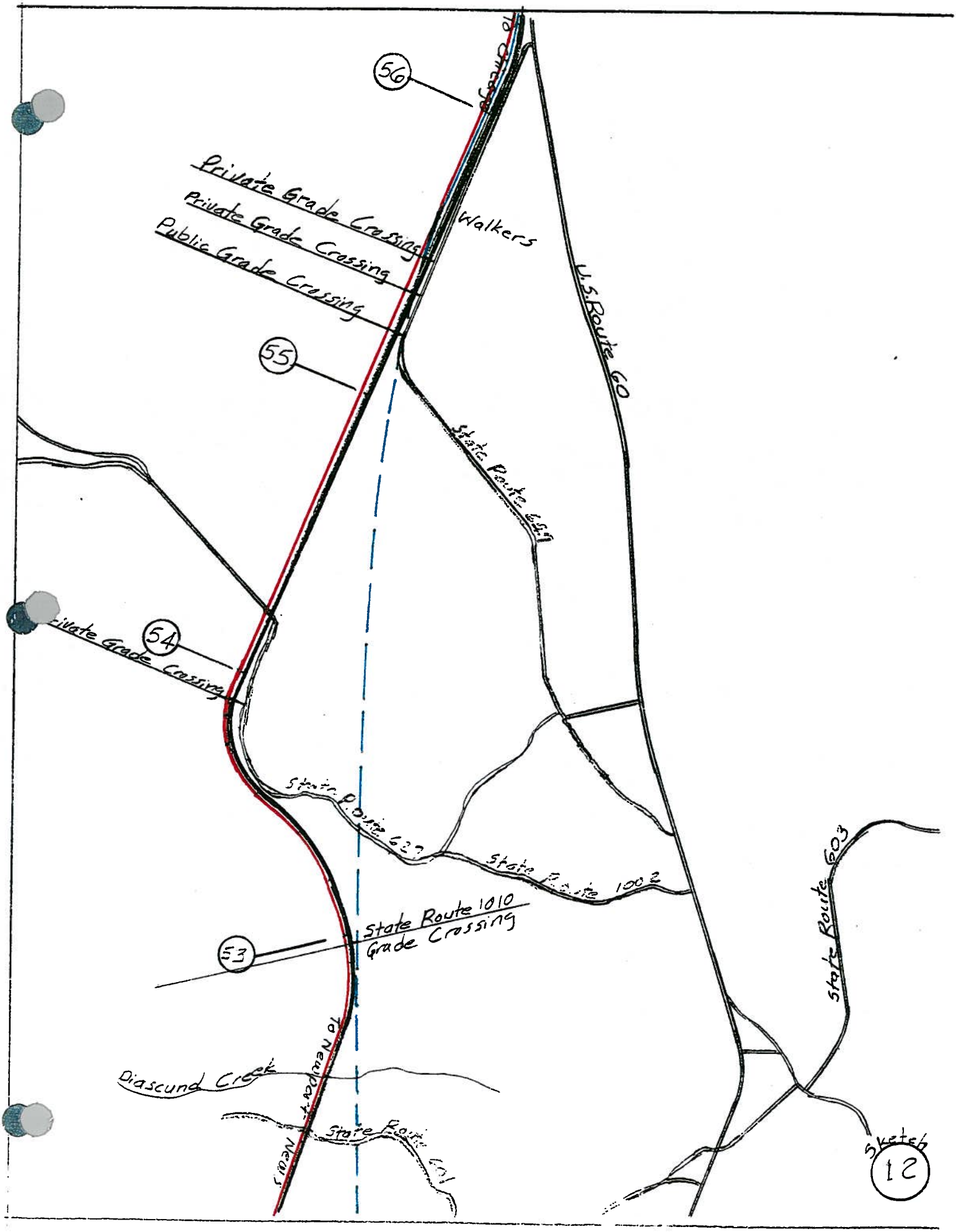

To Chicago
37
Pedestrian U/P
Capital Landing Rd
Colonial Parkway U.P.
O.P
Pedestrian
O.P.
Williamsburg
36
pro
36
Colonial National Historical Parkway
State Route 716
stream
State Route 143
35
pro
35
State Route 199 O.P.
Jones Pond
I-64
pro
34
34
State Route 641
U.S. Route 60
To Newport News
Whiteman
swamp
sketch
1

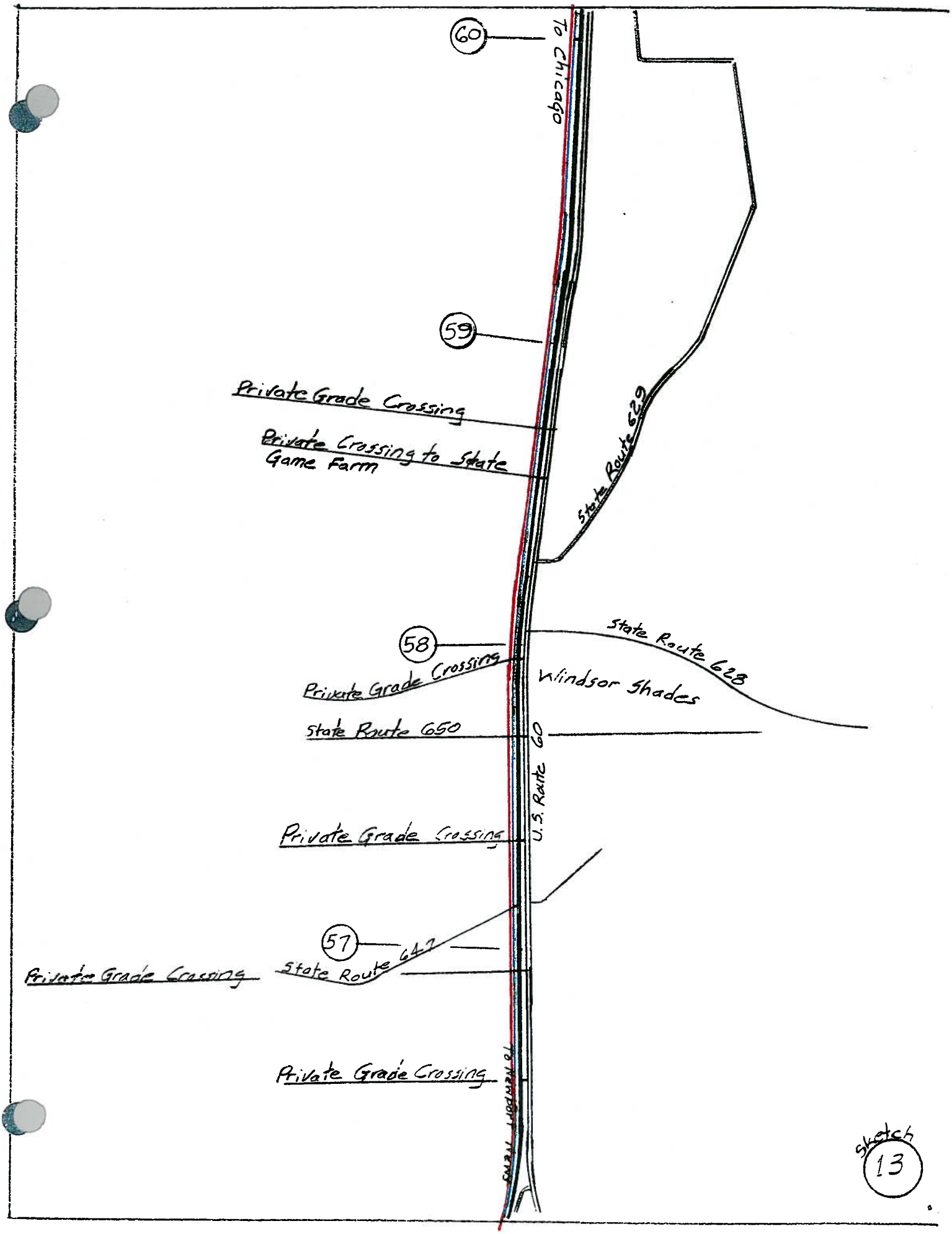

41
To Chicago
State Route 603
State Route 645
40
Pro
40
Schenck Estates
Stream
I64
State Route 645
Pro
39
39
Private Grade Crossing
U.S. Route 60
Williamsburg
Private Grade Crossing
State Route 713
Pro
38
Stream
38
U.S. Route 60
State Route 132
State Route 143
Interchange
Pro
37
Queen Creek
Richmond Road
To Newport News
Henry Street
Capitol Landing Road
Sketch
8


To Chicago
pro
44
Private Grade Crossing
Norge
Unnamed Road
Private Grade Crossing
44
Private Grade Crossing
pro
43
I-64
Skimino Creek
Private Grade Crossing
Private Grade Crossing
43
Private Grade Crossing
Williamsburg Pottery
U.S. Route 60
te Route 614
pro
42
State Route 646
Burkes Corner
42
State Route 646
pro
41
State Route 608
To Newport News
41
sketch
9

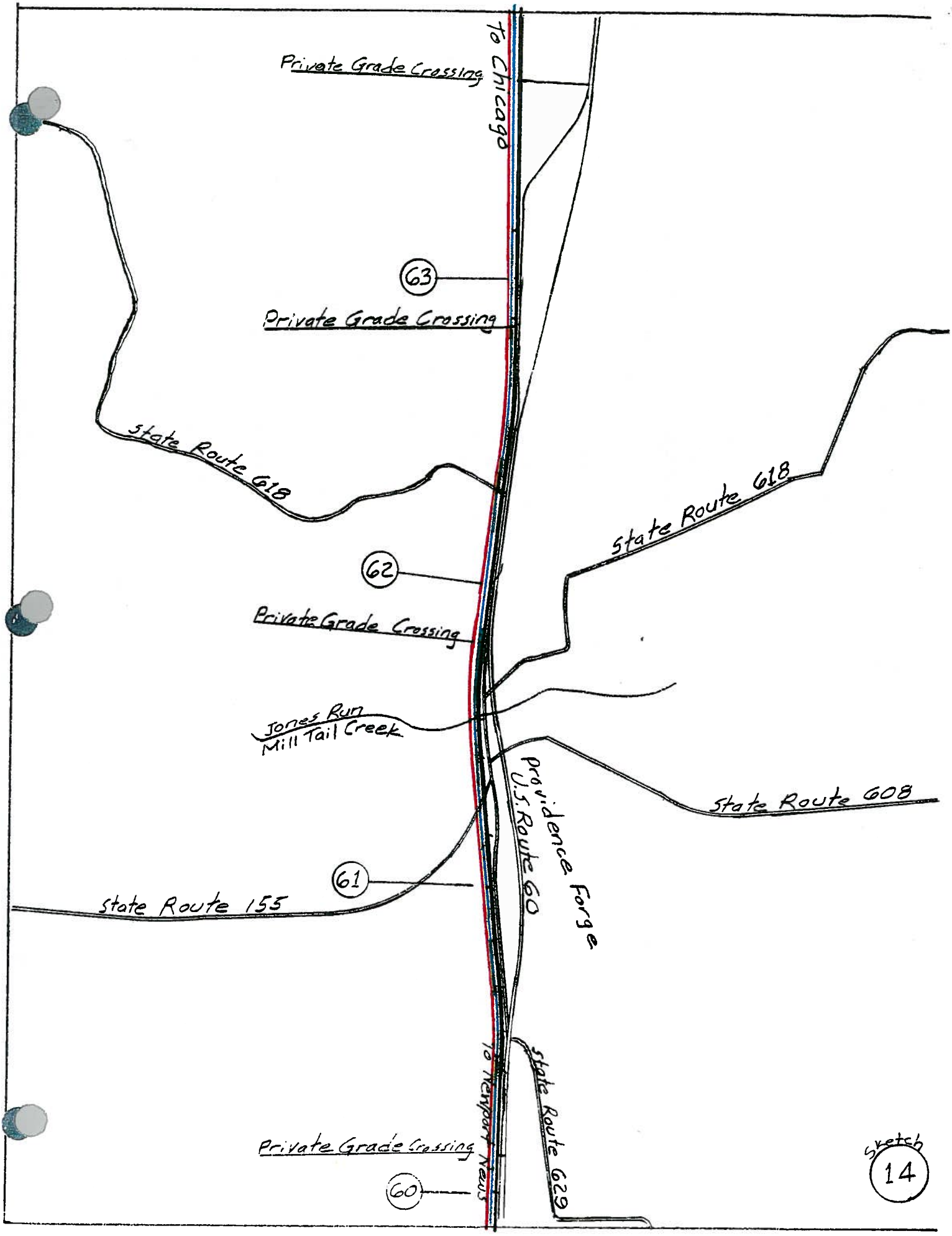

Sketch 10
I 64
State Route 30
State Route 30
U.S. Route 60
To Chicago
Toano
U.S. Route 60
To Newport News
State Route 60
Roadway
45
45
45
45


52
To Chicago
State Route 601
51
State Route 603
50
Bridge
Siding
U.S. Route 60
State Route 601
49
To Newport News
48
I64
State Route 30
sketch
11

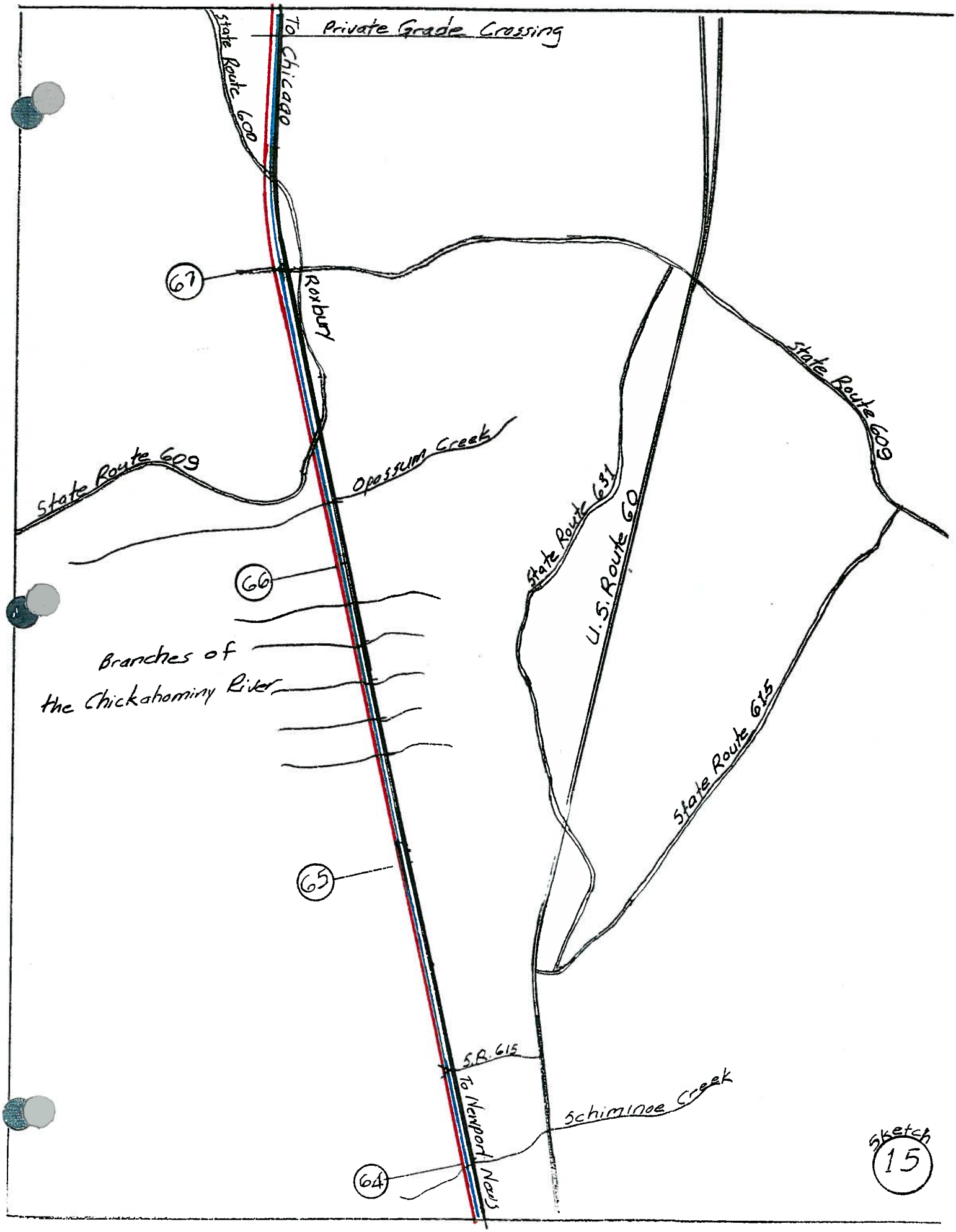

56
To Chesapeake
Private Grade Crossing
Private Grade Crossing
Public Grade Crossing
Walkers
U.S. Route 60
55
State Route 669
54
Private Grade Crossing
State Route 627
State Route 1002
State Route 1010
Grade Crossing
53
To Newport News
Diascund Creek
State Route 603
State Route 621
Sketch
12

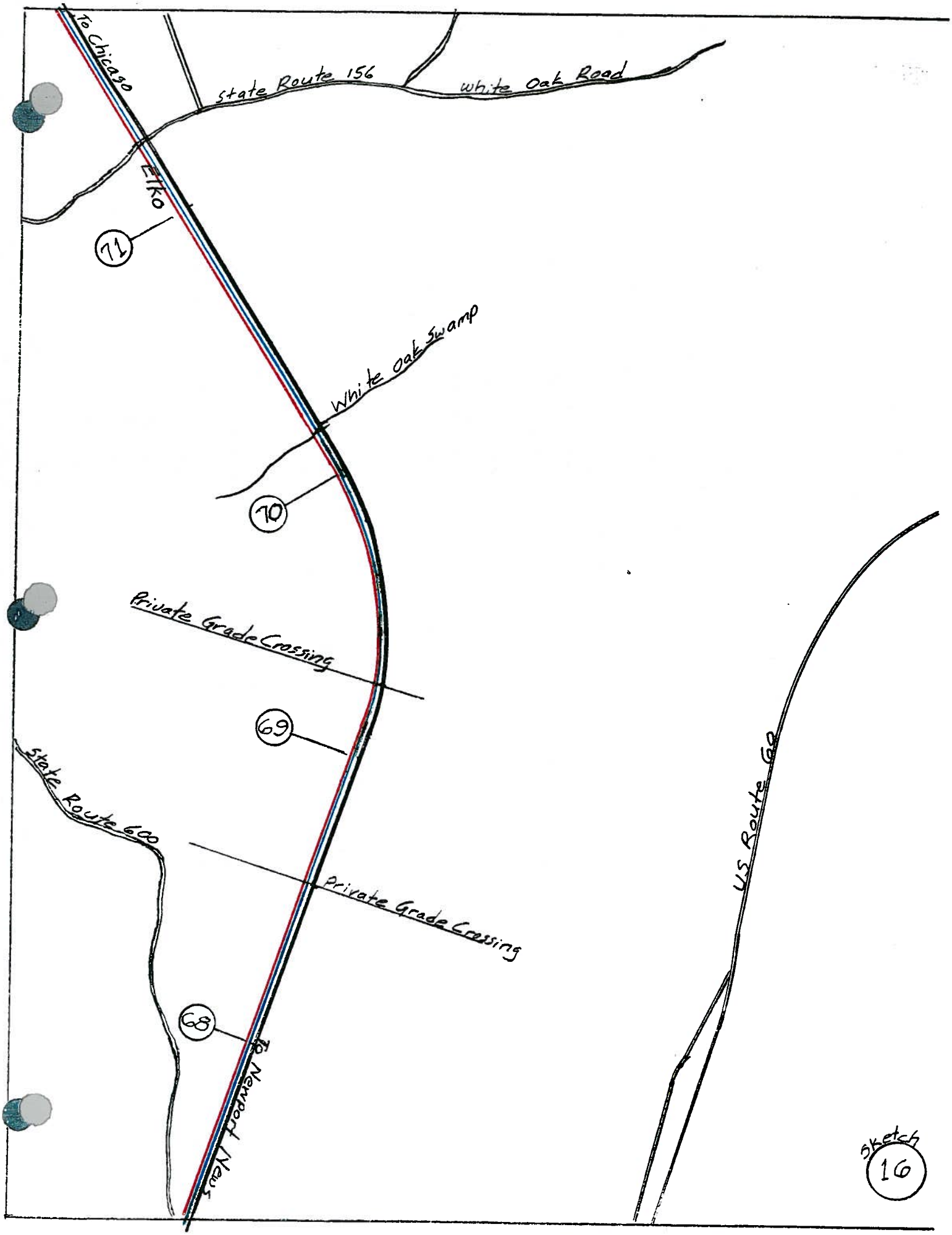

60
To Chicago
59
Private Grade Crossing
Private Crossing to State Game Farm
State Route 629
58
State Route 628
Private Grade Crossing
Windsor Shades
State Route 650
U.S. Route 60
Private Grade Crossing
57
State Route 647
Private Grade Crossing
Private Grade Crossing
To Kenton

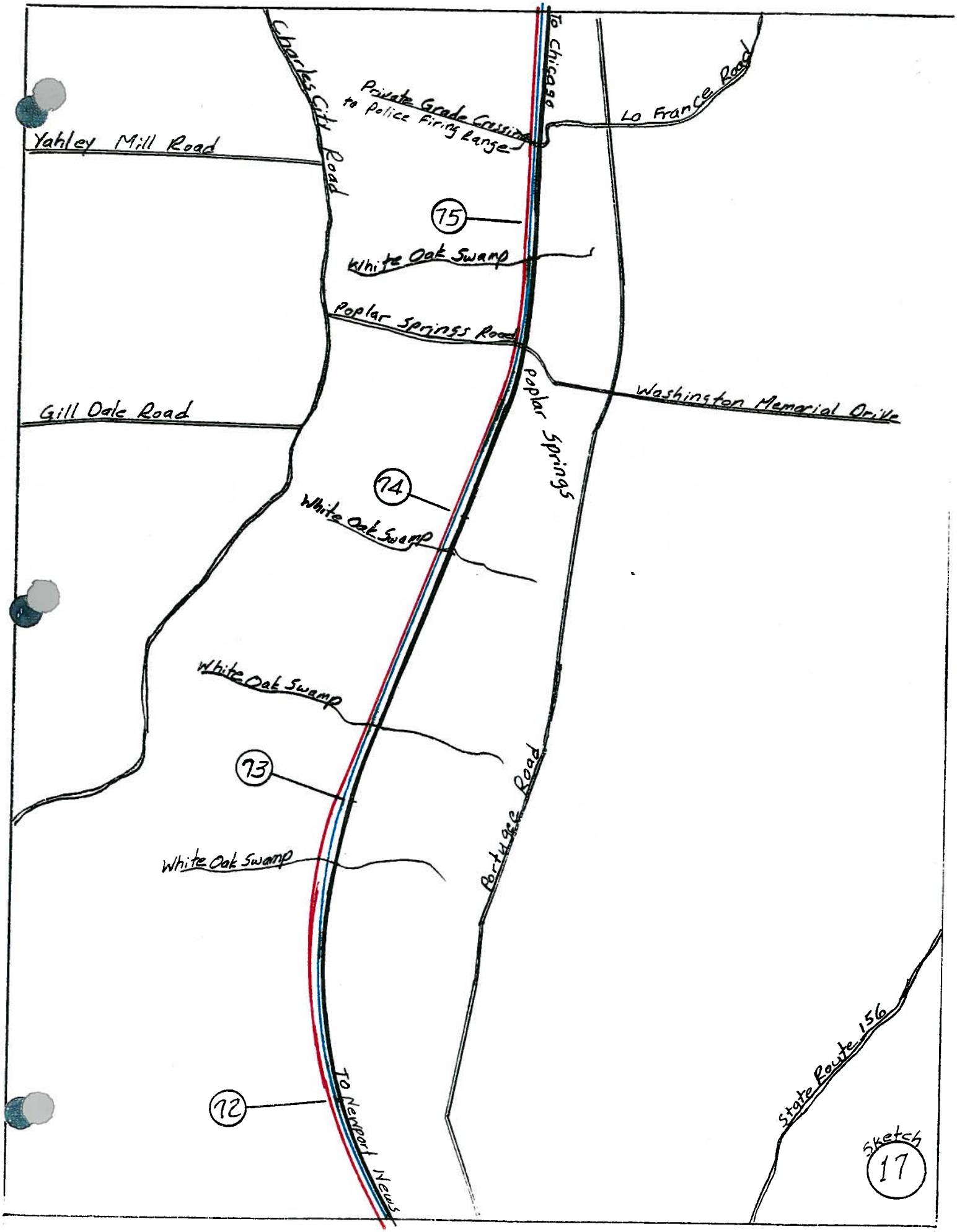
sketch 13

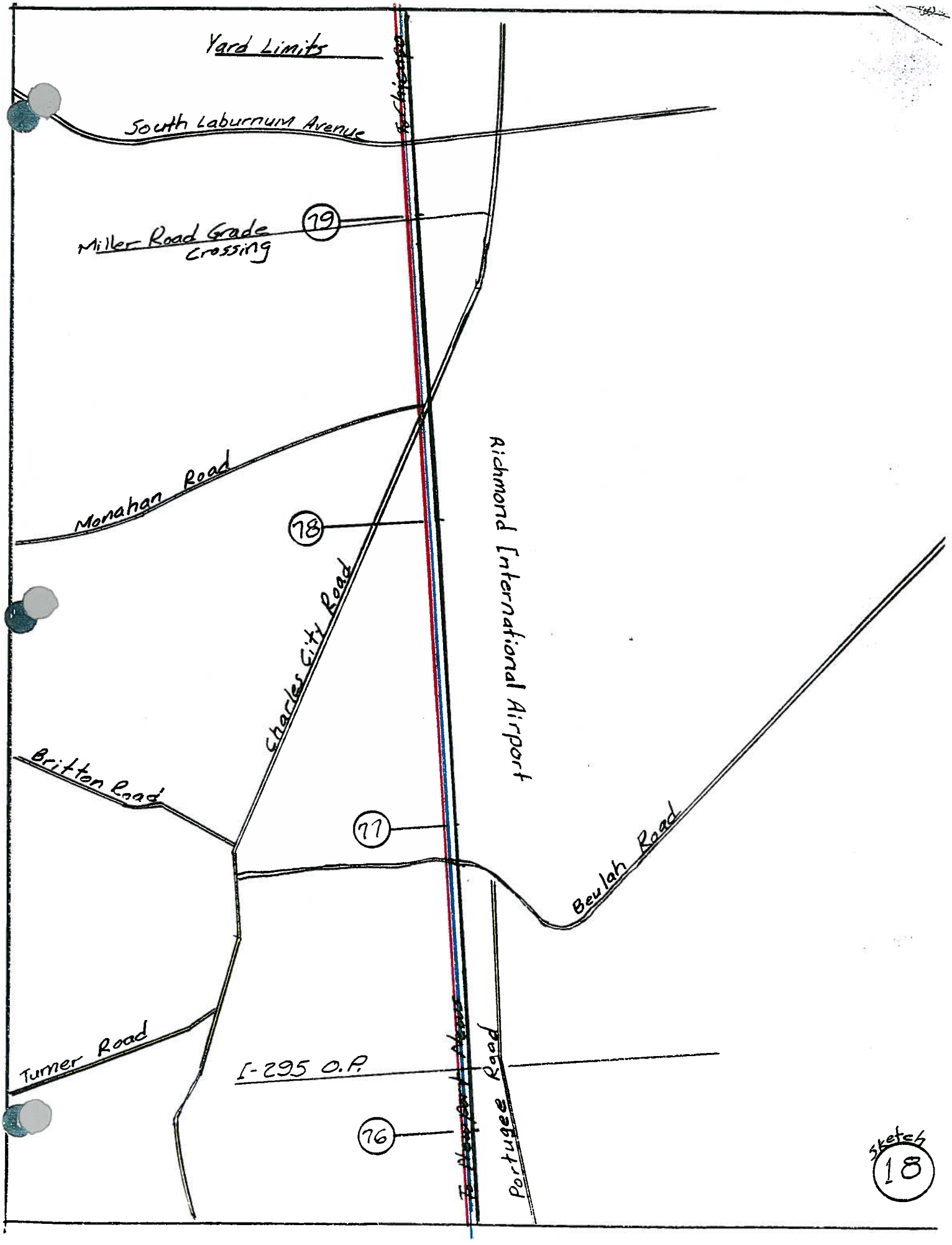

To Chicago
Private Grade Crossing
63
Private Grade Crossing
State Route 618
State Route 618
62
Private Grade Crossing
Jones Run
Mill Tail Creek
Providence Forge
U.S. Route 60
State Route 608
61
State Route 155
To Newport News
State Route 629
Private Grade Crossing
60

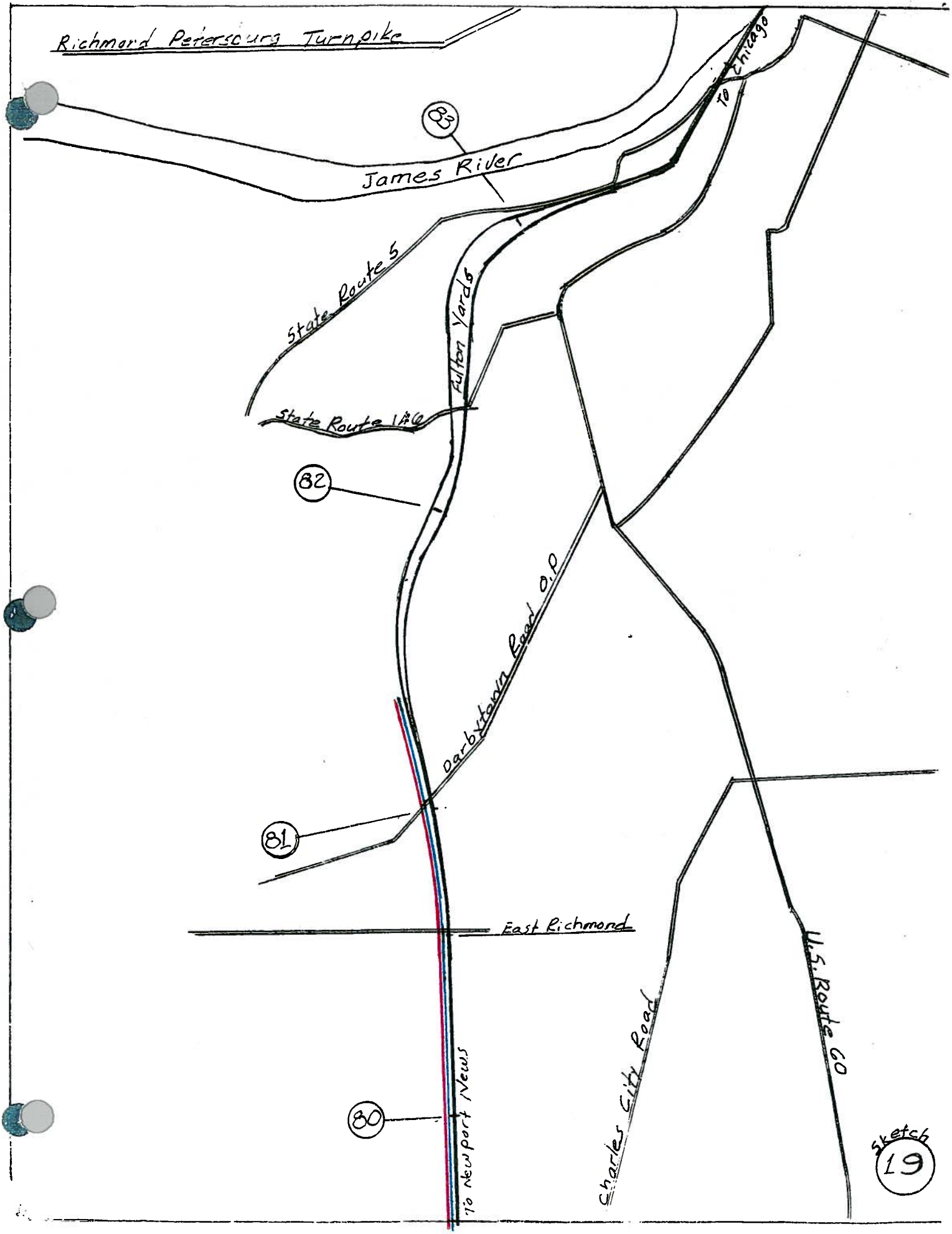
Sketch 14


To Private Grade Crossing
State Route 600
To Chicago
67
Roxbury
State Route 609
Opossum Creek
State Route 609
66
Branches of
the Chickahominy River
State Route 631
U.S. Route 60
State Route 609
State Route 615
65
S.R. 615
To Newport News
Schiminoe Creek
64
Sketch
15


To Chicago
State Route 156
White Oak Road
Elko
71
White Oak Swamp
70
Private Grade Crossing
69
State Route 66
Private Grade Crossing
68
To Newport News
US Route 66
Sketch
16


To Chicago
Charles City Road
Private Grade Crossing to Police Firing Range
Lo France Road
Yahley Mill Road
75
White Oak Swamp
Poplar Springs Road
Poplar Springs
Washington Memorial Drive
Gill Oak Road
74
White Oak Swamp
White Oak Swamp
73
Portugee Road
White Oak Swamp
72
To Newport News
State Route 156
sketch 17


Yard Limits
South Laburnum Avenue
Miller Road Grade Crossing
79
Monahan Road
78
Charles City Road
Richmond International Airport
Britton Road
77
Beulah Road
Turner Road
I-295 O.P.
76
Portugee Road
sketch 18


Richmond Petersburg Turnpike
83
James River
To Chicago
State Route 5
Fulton Yards
State Route 146
82
Darbytown Road O.P
81
East Richmond
U.S. Route 60
Charles City Road
80
To Newport News
sketch
19

APPENDIX H: PUBLIC COMMENTS

Norfolk Southern Corporation
3 Commercial Place
Norfolk, VA 23510-9207

Chris Wichman
Transportation Planner
Hampton Roads Transportation Planning Organization
723 Woodlake Drive
Chesapeake, VA 23320

Mr. Wichman,

Norfolk Southern (NS) appreciates the opportunity to continue to comment on the Hampton Roads Passenger Rail Vision Plan. NS submitted comments to HRTPO in February, and those comments were incorporated into a revised version of the study. We believe that there is still some ambiguity related to the use of NS right-of-way between Norfolk, VA and Petersburg, VA, even in this revised version. Hopefully the material we describe below will resolve those ambiguities.

We would appreciate two sets of clarifications in the final version of the study. The language appearing first below should appear at the front of the report to provide clarity and context regarding the use of NS right-of-way. Additionally, where there is a reference, textual, visual, or otherwise to our right-of-way, we ask that a footnote be placed on that page that reminds the reader of the restrictions NS places on high-speed passenger trains utilizing its corridors. That footnote language appears below as well.

Section 1.1.1

Throughout this study, there will be textual and visual references, explicit or otherwise, to the Norfolk Southern (NS) right-of-way that runs from Norfolk, VA to Petersburg, VA where it then connects to CSX to head to Richmond, VA and points north. NS has strict policies regarding passenger rail and how fast passenger trains may travel on NS right of way (ROW). Those policies are summarized below:

- Where higher speed passenger trains share tracks with conventional freight trains, those high speed trains may not exceed 79 mph.
- Passenger trains operating in excess of 79 mph will require dedicated tracks, and may not exceed 90 mph.
- Passenger trains exceeding 90 mph require their own private right-of-way with at least a 50 foot separation between high speed tracks and freight tracks.

These policies are important in the context of this report as they govern any and all high speed passenger train options utilizing NS right-of-way.

Norfolk Southern Corporation
3 Commercial Place
Norfolk, VA 23510-9207

Footnote to be placed at any mention, textual, visual or otherwise, of Norfolk-Petersburg, Norfolk Southern, Norfolk – Richmond along 460 and any other mention where use of NS ROW is referred to either explicitly or is inferred.

*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger trains utilizing it or encroaching upon it.

We believe this additional language is necessary to ensure that readers clearly understand the use of NS right-of-way, if permitted, would only be permitted in a manner that consistent with NS policy, which has conditions not completely compatible with high-speed rail service.

Additionally, NS requests that its passenger policy requirements regarding passenger rail speeds be included in any and all future presentations where NS right-of-way is referred to in any manner.

Lastly, NS requests that any and all references to its Michigan line transaction, specifically in Section 3.1.1 on page 3-3, be removed from future versions of these reports. That transaction was unique and NS does not intend to pursue such a transaction with the Norfolk-Petersburg corridor.

NS appreciates having a voice at the table with the HRTPO and we look forward to continuing our relationship in the future.

Best regards,

Scott Plum

FUTURE
OF HAMPTON ROADS, INC.

Visioning the Future for America's First Region

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Since 1983

September 25, 2014

RESOLUTION BY THE BOARD OF DIRECTORS, FUTURE OF HAMPTON ROADS, INC.

Whereas the Hampton Roads Transportation Planning Organization (HRTPO) began the development of a High Speed Rail Vision Plan in 2009 to evaluate the potential of high speed and enhanced passenger rail service alternatives for the region, the search has resulted in a number of technical reports and has been described as near completion; and

Whereas rail service, specifically high speed rail, has been identified by Future of Hampton Roads as the key transportation element necessary to maintain regional economic competitiveness by effectively connecting the region to economic centers in the northeast, southeast and around the country; and

Whereas it is the opinion of Future of Hampton Roads' Board of Directors that a final report "High Speed Rail Vision Plan" from HRTPO is vital to the region's ability to pursue funding and support for key studies, and improvements in infrastructure for rail service;

Therefore, be it resolved by the Board of Directors for Future of Hampton Roads that the organization formally urges the HRTPO to complete and release the High Speed Rail Vision Plan as soon as possible.

Respectfully submitted,

William W. Crow
Chairman, Future of Hampton Roads

COMMONWEALTH of VIRGINIA

Jennifer L. Mitchell
Director

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October 28, 2014

Camelia Ravanbakht
Interim HRTPO Executive Director
The Regional Building
723 Woodlake Drive
Chesapeake, VA 23320

HRTPO
OCT 30 2014
RECEIVED

Dear Camelia:

Thank you for the opportunity to work with the Hampton Roads Transportation Planning Organization (HRTPO) and provide comments to HRTPO's High Speed Rail Vision Plan Alternatives Analysis. As the Alternatives Analysis has been underway, the Department of Rail and Public Transportation (DRPT) has enhanced intercity passenger rail service to Hampton Roads, as evidenced by new service to Norfolk, concluded the Richmond to Hampton Roads Tier I EIS in 2012, and the included three Hampton Roads area legislators in the Virginia-North Carolina Rail Compact. Additionally, DRPT has programmed $82 million in funding in the approved FY2015 – FY2020 six-year plan for service expansion to Norfolk and $20 million in rail funds for the proposed multimodal station in Newport News. As always, we urge the HRTPO to work with DRPT, FRA and the host railroads for coordinated intercity passenger rail improvements. We are committed to working with HRTPO to advancing higher speed rail improvements in a constructive manner that is consistent with Federal priorities and reasonably expected estimates for future funding.

In 2002, the Federal Railroad Administration published the Tier I Record of Decision (ROD) for the Southeast High Speed Rail (SEHSR) from Washington D.C. to Charlotte, North Carolina. The Tier I ROD identified the CSX right-of-way (ROW) as the preferred corridor between Richmond, VA and Washington, D.C. for high speed rail in order to minimize impacts, reduce initial capital investment, and generate benefits of higher speeds in an achievable timeframe. Since 2003, DRPT has been working in collaboration with the North Carolina Department of Transportation and the Federal Railroad Administration (FRA) to conduct the Southeast High Speed Rail (SEHSR) Tier II Environmental Impact Statement (EIS) from Richmond, Virginia, to Raleigh, North Carolina.

In 2010, DRPT was awarded funding from the FRA's High Speed Rail Program to advance the SEHSR Washington D.C. to Richmond segment Tier II EIS. DRPT is actively advancing the

SEHSR Washington D.C. to Richmond Tier II EIS, as well as other potential capital improvements in the corridor that would benefit current passenger rail services. It is critical that DRPT strictly adhere to the requirements of National Environmental Policy Act (NEPA) of 1969 and that clear communication is provided to the public throughout the Washington D.C. to Richmond Tier II EIS process.

FRA has demonstrated that it will support and invest in rail projects that are consistent with its nationwide policies, and projects that have clear and consistent support from the residents of the region. The Alternatives Analysis has been presented as a parallel/concurrent study (to SEHSR efforts) that has the effect of confusing the audience and potentially risking FRA's support of existing plans in the region. As such, DRPT requests that the HRTPO discontinue making reference to the HRTPO High Speed Passenger Rail Vision Plan Alternatives Analysis as a parallel/concurrent study to the FRA sponsored SEHSR studies that are being conducted by DRPT and/or in collaboration with North Carolina DOT in written format and/or public forum.

DRPT wishes to provide the following observations regarding assumptions that have been made in the HRTPO's Hampton Roads High Speed Passenger Rail Vision Plan Alternatives Analysis that have recently been conducted.

- The 2025 ridership forecast assumptions include development of SEHSR service and NEC Future service. This level of ridership is based on approximately $165 billion of capital improvements in the NEC, for which there is no committed sources of funding identified. Absent any committed sources of state or Federal revenues, there is no guarantee that SEHSR service will be implemented by 2025, and NEC Future service is currently projected out to 2040. As such, we believe the 2025 ridership forecasts may be overly optimistic.

- The market analysis was based on travel markets outside of the SEHSR corridor and well outside of the Hampton Roads Region travel market. The ridership forecasts assume speeds of 130MPH and 220MPH that are unobtainable between Richmond and Washington, D.C. without a fully separated greenfield alignment. This assumption is inconsistent with the SEHSR Tier I EIS ROD issued in 2002.

- The Alternatives Analysis report claims no environmental fatal flaws for the recommended alternative. However given the significant presence of wetlands and sensitive resources in this corridor, DRPT has serious concern with this assumption. The U.S. Route 460 Location Study: Draft Supplemental EIS prepared by VDOT documents many of the environmental impacts associated with a potential greenfield project in this corridor. This study assumes use of CSX and Norfolk Southern (NS) ROW in the description of alternatives at speeds of 130MPH and 220MPH. The HRTPO staff and their consultant have been notified that speeds of 79MPH on NS and 90MPH on CSX ROW are the maximum allowable speeds. Further, ROW is not available for the barrier separation that has been identified in the Alternatives Analysis report to accommodate speeds in excess of 130MPH on the CSX or NS ROW.

- The HRTPO study assumes the use of push-pull or double ended trains that have diesel power cars; however, Amtrak does not allow push-pull or double ended trains and will require a "wye" track to turn the trains.

- DRPT is concerned that the capital cost estimate of $8B ($2013) for 193 mile greenfield project between Washington D.C. and Norfolk, VA may be low. Compared to the capital costs identified in the 2010 Amtrak's Vision for High Speed Rail in the Northeast Corridor, which provides a 220MPH service on the existing Northeast Corridor ROW between Washington D.C. and New York City and separate ROW between New York City and Boston MA at $117B for 439 miles. At $260M/mile, the actual cost of the 220MPH service between Washington D.C. to Norfolk, VA would cost in the neighborhood of $51B. We understand and appreciate that the costs of purchasing a 100-foot section of right-of-way in the proposed corridor would be lower than urban greenfield costs in the northeast corridor. However based on this benchmarking, the actual costs of positive train control systems and electrification, and the number of river crossings in the corridor that will require new infrastructure, we are concerned that the capital cost estimates identified in the Alternative Analysis may be understated. As such the resulting cost-benefit ratios to be overly optimistic. As stated in section 4.4, additional capital cost estimating will need to be conducted during any future studies.

- Any assessment of project delivery methods, including public-private partnerships, should be based on realistic prospective of funding resources including the availability of state and Federal funding sources. The comparison of potential project delivery options to the public-private partnerships for managed lane projects does not take into account that in the managed lane projects, the developer has assumed toll revenue risk. The study has cited a number of news articles as evidence of a viable business model for this project. While section 8.2 cites "the lack of political will on the part of the public sector partner" as the primary reason that these previous initiatives have failed, we suspect that the actual reasons are much more complicated and market-driven. DRPT would expect that any future analyses of higher speed rail alternatives would provide a more detailed analysis of project delivery options that would take into account Virginia's legislative framework, market conditions, approaches to risk allocation and achievable implementation timeframes.

Thank you for your ongoing collaboration in transportation and high speed rail planning initiatives. We appreciate your strong support and advocacy for passenger rail service in the Commonwealth, and we look forward to working with HRTPO to advance these initiatives in the future. Please feel free to contact me if you have any questions or concerns.

Best regards,

Jennifer Mitchell

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